Fast Pattern Matching-based Direct Mode Decision Algorithm

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Abstract. In H.264, B frame bi-directional predictions and its DIRECT mode coding are included to enhance video compression efficiency. However, such tools are complex and result in a long computation time. This paper proposes a fast DIRECT mode prediction algorithm that enables to save B frame encoding time significantly by determining DIRECT mode (DM) at an early stage through optimal mode pattern matching. Simulations show that the proposed algorithm can determine DM without a complex mode decision process for 42% more macroblocks than Jin’s algorithm.

Keywords: B frame encoding, DIRECT mode, H.264, video compression.

1 Introduction

These days, many multimedia have been widely provided. In these services, image compression techniques play a critical role in reducing data size and thus, allowing to transmit and to store image data with less resources [1, 2, 3]. Among them, H.264 [4] is the most recently developed image compression standard. Many compression tools are introduced for the H.264 standard in order to significantly enhance compression efficiency. Such tools include B frame encoding [5] and its DIRECT mode [6].

Despite the high coding efficiency of B frame encoding and its DIRECT mode, these tools are considered to be one of the most time-consuming tasks since this requires complicated motion estimations and bi-directional predictions. To save the coding time, some research works have been proposed, which enable an early decision on DIRECT mode (DM) [7, 8]. One of such works is Jin’s algorithm [9]. This scheme exploits the strong relations of optimal modes and rate-distortion costs (RDcost) between the macroblock (MB) to be currently encoded and its co-located

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MB. However, they have still required a complex mode decision process, which is the limitation of Jin’s algorithm. To resolve its limitation, this paper proposes a fast DIRECT mode decision.

2 Fast Pattern Matching-based Direct Mode Decision Algorithm

Jin’s algorithm [9] exploits the strong relations of optimal modes and rate-distortion costs (RDcost) between the macroblock (MB) to be currently encoded and its co-located MB. By determining DM coding for the MB without a complex mode decision process, it increases B frame encoding speed significantly. However, the optimal mode of considerable MBs can be DIRECT mode although they do not satisfy conditions of Jin’s algorithm. This is true specially when video images are complicated and move fast. In such cases, Jin’s algorithm may not perform well because many MBs do not satisfy the conditions. Thus, the algorithm needs to run a long complex mode decision process for the MBs, increasing B frame encoding time.

To resolve this problem, the proposed algorithm extends the Jin’s algorithm so that it can determine DIRECT mode not only for MBs satisfying Jin’s conditions but also for MBs not satisfying. The algorithm is summarized as follows. First, in the case of MBs satisfying Jin’s conditions, the proposed algorithm does the same thing of the Jin’s algorithm. The main contribution of the proposed algorithm lies in the MBs not satisfying Jin’s conditions. To determine DIRECT mode for such MBs, the algorithm is proposed to locate MBs in the previous and the next P frames and the previous B frame, which may correspond to the MB encoded in the current frame. For the pattern matching, optimal modes of MBs surrounding the current MB are used as the pattern to be compared in previously encoded frames. This is because, in most cases, objects in a frame cannot move too far in subsequent frames. Through pattern searching in the searching area, the MB corresponding to the current MB can be located in previous frames. If the located MB’s optimal mode is DIRECT mode, the possibility that the optimal mode of the current MB is DIRECT mode can be high since the located MB may correspond to the current MB. However, this cannot be always true. If a MB satisfies the condition given above, the proposed algorithm encodes the MB in DIRECT mode without a complex mode decision process, saving encoding time. Otherwise, all the mode decision calculations are required. In the next section, simulation results and their analysis for this algorithm are given.

3 Simulation Results

The proposed algorithm is incorporated into JM 14.2 [10] under the following conditions: RDOptimization=1, GOP=IBBP, encoding frames including I,B,P=199, MV search range=32, resolution={qcif, cif}. The results are shown in Table 1.

Simulation results show that the proposed algorithm improves the accuracy of direct mode decisions by up to 42%, compared to the accuracy of Jin’s algorithm. Especially, when direct mode MB ratio to total MB is low, the proposed algorithm outperforms Jin’s algorithm. This is because, in this case, many MBs cannot satisfy
the condition of Jin’s algorithm and thus, Jin’s algorithm needs to calculate complex mode decisions, suffering long encoding time.

Table 1. Comparisons of direct mode decision accuracy (QP=20).

<table>
<thead>
<tr>
<th>Sequences</th>
<th>Size</th>
<th>Total # DM</th>
<th>DM % in MBs</th>
<th>Jin # DM</th>
<th>Jin Hit %</th>
<th>Prop #DM</th>
<th>Prop Hit %</th>
</tr>
</thead>
<tbody>
<tr>
<td>News</td>
<td>QCIF</td>
<td>3890</td>
<td>79%</td>
<td>4088</td>
<td>87%</td>
<td>4195</td>
<td>90%</td>
</tr>
<tr>
<td>Foreman</td>
<td>QCIF</td>
<td>1772</td>
<td>34%</td>
<td>1980</td>
<td>47%</td>
<td>2263</td>
<td>67%</td>
</tr>
<tr>
<td>Container</td>
<td>QCIF</td>
<td>4284</td>
<td>83%</td>
<td>4516</td>
<td>85%</td>
<td>4815</td>
<td>88%</td>
</tr>
<tr>
<td>Bus</td>
<td>CIF</td>
<td>7084</td>
<td>36%</td>
<td>8138</td>
<td>57%</td>
<td>8952</td>
<td>73%</td>
</tr>
<tr>
<td>Stefan</td>
<td>CIF</td>
<td>8064</td>
<td>47%</td>
<td>8878</td>
<td>63%</td>
<td>9742</td>
<td>79%</td>
</tr>
<tr>
<td>Waterfall</td>
<td>CIF</td>
<td>9800</td>
<td>51%</td>
<td>11287</td>
<td>55%</td>
<td>13182</td>
<td>72%</td>
</tr>
</tbody>
</table>

4 Conclusions

To enhance B frame encoding speed, the work proposes a fast direct mode decision algorithm that extends Jin’s algorithm and thus, can make direct mode decisions not only for macroblocks satisfying Jin’s conditions but also for macroblocks not satisfying. This allows reducing B frame encoding time by encoding more macroblocks in DIRECT mode without executing long mode decision processes.

References