A Zero-Value Prediction Technique for Fast DCT Computation

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Introduction

- Discrete Cosine Transform (DCT) is the most commonly used transform for video coding (JPEG, MPEG H26x etc).

Problem

- DCT is a very computationally expensive task.
- DCT requires a measurable amount of energy and many operations.

Reducing the number of operations and energy consumption of DCT becomes important.
Our Proposal

A Zero-Value Prediction Technique for Fast DCT Computation

**Advantage**

- Reduces the number of DCT and quantization operations.
- Reduces energy consumption.
- Increases DCT operation speed.

**Disadvantage**

- The picture quality deteriorates.
The feature of DCT

The high frequency components at the DCT output are concentrated nearby zero value.

Input data (Pixel Level)

Output data (DCT coefficient)
The feature of Quantization

The probability of elements in the encoding block to become zero after quantization is very high.

In the case Quantization step = 16

Input data (DCT coefficient) Quantization output data
Zero-Value Prediction Technique

When the DCT output $N$ zeros, we predict the remaining result is also zero without actual DCT computing.

In the case with $N=2$

Reducing operations for 35 DCT coefficients is possible.
A Zero-Value Prediction Technique

Example (1/2)

**DCT coefficient**

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<th>Conventional Technique</th>
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<thead>
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<th>A Zero-Value Prediction technique</th>
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The prediction error increases but most of the DCT coefficients will be zeros after quantization.
A Zero-Value Prediction Technique

Example (2/2)

*Quantization output data*

**Conventional Technique**

**A Zero-Value Prediction technique**

When a picture is decoded, the prediction error degrades image quality.
Using the MPEG software from MPEG Software Simulation Group

- 2D-DCT algorithm use addition 1024 and multiplication 1024 times per 1 block.
- 2D-DCT use partitionable method (1D-DCT \(\times\) 1D-DCT).
- Raster scan order of DCT computation.

**Video benchmarks**

- missa: QCIF 150frame
- carphone: QCIF 382frame
- foreman: QCIF 298frame
- salesman: CIF 300frame
The PSNR is low when N is small.
The PSNR does not change a lot after N=9.
Operation reduction rate as a function of $N \ (DCT)$

The reduction rate is high when $N$ is small.

- The reduction rate is high when $N$ is small.
The reduction rate is high when $N$ is small (similarly to the DCT operation).
Assumption to accept $N=9$ as a tradeoff for both picture quality and the reduction rate.

The PNSR decreases by 1.07dB.

Example of reconstructed picture for $N=9$
Conclusion

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- When N=9, the number of computations is reduced by 29% for DCT and by 59% for quantization.
- The average PSNR value degreases by -1.6dB.

Future work

- Estimating the effect of the proposed technique on energy consumption.
**Comparison of the algorithm**

The number of operations per 1 block.

Normal: addition 1024 and multiplication 1024 times.
Chen: addition 416 and multiplication 224 times.
FFT: addition 464 and multiplication 176 times.

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<tr>
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<th>Number of operation</th>
<th>Average PSNR degradation (dB)</th>
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<tr>
<td></td>
<td>Max</td>
<td>Min</td>
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<tr>
<td>Normal</td>
<td>22.9%</td>
<td>11.8%</td>
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<tr>
<td>Chen</td>
<td>17.4%</td>
<td>7.9%</td>
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<tr>
<td>FFT</td>
<td>23.3%</td>
<td>13.6%</td>
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