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Title
Energy-Efficient Image Communication for Wireless Sensor Networks

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Energy-Efficient Image Communication for Wireless Sensor Networks

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Introduction: Image Communication with Sensors

Image Communication

- Transmission of compressed images is believed to be more efficient than transmission of uncompressed images, however very little quantitative studies exist in the context of resource-constrained sensor platforms
- Traditional JPEG implementations used far greater precision than is necessary in light of the rounding occurring in the quantization process
- In contrast, we adopt an energy-aware approach to ensure JPEG computations utilize the minimum precision needed
- Using optimized JPEG implementations we examine detailed energy/speed tradeoffs between different transmission strategies

Problem Description: Efficient Mapping of JPEG into Sensor Platforms

DCT and Quantization Steps

- DCT and Quantization steps consist of large numbers of additions and multiplications involving real numbers
- Straightforward way of implementing such computations is to use floating-point, but processors used in sensors lack dedicated floating-point hardware
- Emulating floating-point via integer operations retains high precision but is extremely slow
- Floating-point accuracy is rarely required in embedded environments → processor cycles and memory wasted for computing overly precise results
- We implement the computations in fixed-point arithmetic with consideration of the precision needed and the native word-length of the processor

Proposed Solution: Precision Optimized JPEG

DCT & Quantization: IJG vs Proposed

<table>
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<th>Method</th>
<th>Type</th>
<th>DCT Execution</th>
<th>Quantization Execution</th>
<th>Total Execution</th>
<th>Code Size (bytes)</th>
<th>Resource (kb)</th>
<th>Energy [mJ]</th>
<th>Power [μW]</th>
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<td>1</td>
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<td>203,810</td>
<td>18,695</td>
<td>222,505</td>
<td>1,961</td>
<td>1,951</td>
<td>55.6</td>
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<td>33,695</td>
<td>1,961</td>
<td>1,951</td>
<td>55.6</td>
<td>21.8</td>
</tr>
</tbody>
</table>

- Comparison against the Independent JPEG Group (IJG) library for an 8x8 DCT and quantization on the ATmega128 processor used in the Cyclops platform
- Quality setting at Qtab = 50 (standard JPEG quantization table)
- Proposed approach leads to better performances due to the custom precision approach

Region of Interest Coding

Successive Images

- Instead of transmitting each frame individually, exploit temporal dependencies between frames.
- Use inter-coded frames (I-frames) and difference-coded frames (D-frames)