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Energy Tradeoffs in Image Communication among Resource-Constrained Image Sensors
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Energy Tradeoffs in Image Communication for Resource-Constrained Image Sensors

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Introduction: Image Communication with Sensors

Image Communication

- Common in wireless image sensors
- State-of-the-art sensor platforms such as Cyclops still rely on transmission of uncompressed RAW images
- Cyclops
 - Wireless communication speed = 19.2 kbps
 - Time to transmit 128x128 grayscale image = 8 s
- Image compression desirable since wireless transmission of a bit can require several orders of magnitude more than a single computation

Image Compression

- Lossy compression: exploit known limitations of the human eye, small color changes are perceived less accurately than small changes in brightness
- JPEG widely used on PC platforms, cameras, etc.
- We have developed a complexity-optimized JPEG implementation targeting resource-constrained sensors

Problem Description: Transmit or compress then transmit?

- Compression involves costs in memory, image quality, computation time and energy, but saves transmission time and energy
- These general facts are well known, but little experimental work exploring the specific aspects of these tradeoffs exist
- Work presented here explores these in the context of a Cyclops platform with low resolution, grayscale images



Proposed Solution: JPEG Encoder on Cyclops

JPEG Image Compression on Cyclops

- C code adopted from Independent JPEG Group's library
- Customized to fit into Atmel ATmega128 processor and small amount of external memory on Cyclops
- Compression ratio & image quality can be traded off by using different quantization tables
- Compression ratios of 4x ~ 6x achieved for 64x64 and 128x128 grayscale/color images with acceptable image quality

Compressed Bird Nest Images

- Actual 128x128 grayscale images from James Reserve
- Quality setting (which ranges over 0~100) of 35 provides good compression performance with insignificant visual artifacts



RAW: 131 kb



JPEG: 25 kb

Performance Results

- 128x128 grayscale image
 - Assuming 8 MHz processor clock speed and 19.2 kbps transmission speed
 - Sending 1 bit takes same energy as doing 750 instructions
 - 802.15.4 radio: 3000 nJ/bit
 - ATmega128 processor: 4 nJ/op
 - Similar results across other resolutions

Code Size and Speed Comparisons

	RAW	JPEG*
Code Size	19 kb	25 kb
Computation Time	1 s	3.4 s
Transmission Time	6.8 s	1.1 s
Total Time	7.8 s	4.5 s

1.7x reduction

Energy Comparisons

	RAW	JPEG*
Computation Energy	32 mJ	109 mJ
Transmission Energy	402 mJ	77 mJ
Total Energy	434 mJ	186 mJ

2.3x reduction

* Typical performance, can vary with images