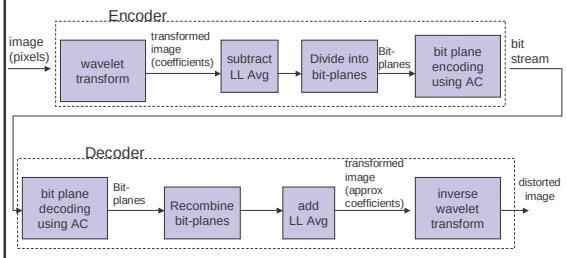
CSE 490 GZ
Introduction to Data Compression
Winter 2004

UW Image Coder

UWIC

- A simple image coder based on
  - Bit-plane coding
    - Significance pass
    - Refinement pass
  - Arithmetic coding
  - Careful selection of contexts based on statistical studies
- Implemented by undergraduates Amada Askew and Dane Barney in Summer 2003.

UWIC Block Diagram

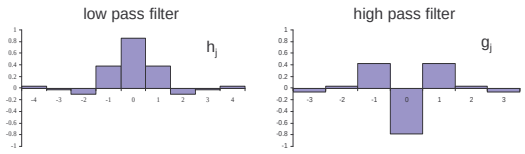


Arithmetic Coding in UWIC

- Performed on each individual bit plane.
  - Alphabet is Σ={0,1}
- Uses integer implementation with 32-bit integers. (Initialize L = 0, R = 2^{32}-1)
- Uses scaling and adaptation.
- Uses contexts based on statistical studies.

Wavelet Transform

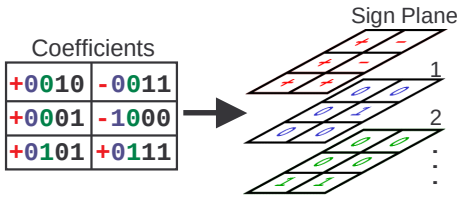
- Standard Daubechies 9/7 Filters



Original Barbara Image

Subtract Ave of Low Res Subband

Divide into Bit-Planes



Coding the Bit-Planes

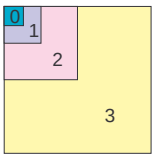
- Code most significant bit-planes first
- Significance pass for a bit-plane
  - First code those coefficients that were insignificant in the previous bit-plane.
  - If a coefficient becomes significant then code its sign.
- Refinement pass for a bit-plane
  - Code the refinement bit for each coefficient that is significant in a previous bit-plane

Contexts (per bit plane)

- Significance pass contexts:
  - Contexts based on
    - Subband level
    - Number of significant neighbors
  - Sign context
- Refinement contexts
  - 1st refinement bit is always 1 so no context needed
  - 2nd refinement bit has a context
  - All other refinement bits have a context
- Context Principles
  - Bits in a given context have a probability distribution
  - Bits in different contexts have different probability distributions

Subband Level

- Image is divided into subbands until LL band (subband level 0) is less than 16x16
- Barbara image has 7 subband levels



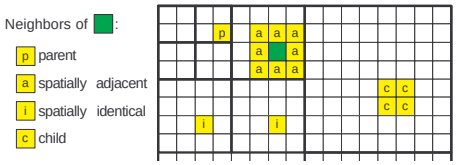
Statistics for Subband Levels

Barbara (8bpp)

Subband Level	# significant	# insignificant	% significant
0	144	364	28.3%
1	272	1048	20.6%
2	848	4592	15.6%
3	3134	23568	11.7%
4	12268	113886	9.7%
5	48282	504633	8.7%
6	190003	2226904	7.8%

Significant Neighbor Metric

- Count # of significant neighbors
  - children count for at most 1
  - 0,1,2,3+



Number of Significant Neighbors

Barbara (8bpp)

Significant neighbors	# significant	# insignificant	% significant
0	4849	2252468	.2%
1	13319	210695	5.9%
2	22276	104252	17.6%
3	30206	78899	27.7%
4	33244	55841	37.3%
5	27354	39189	41.1%
6	36482	44225	45.2%
7	87566	91760	48.8%

Refinement Bit Context Statistics

Barbara (8bpp)

	0's	1's	% 0's
2nd Refinement Bits	146,293	100,521	59.3%
Other Refinement Bits	475,941	433,982	53.3%
Sign Bits	128,145	130,100	49.6%

- Barbara at 2bpp: 2nd Refinement bit % 0's = 65.8%

Context Details

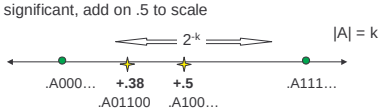
- Significance pass contexts per bit-plane:
  - Max neighbors* num subband levels contexts
  - For Barbara: contexts for sig neighbor counts of 0 - 3 and subband levels of 0-6 = 4*7 = 28 contexts
  - Index of a context.
    - Max neighbors * subband level + num sig neighbors
    - Example num sig neighbors = 2, subband level = 3, index = 4 * 3 + 2 = 14
- Sign context
  - 1 contexts
- 2 Refinement contexts
  - 1st refinement bit is always 1 not transmitted
  - 2nd refinement bit has a context
  - all other refinement bits have a context
- Number of contexts per bit-plane for Barbara = 28 + 1 +2 = 31

Max Heap

- Used in significance pass to decide which coefficient to code next
  - Goal code coefficients most likely to become significant
- All non-empty contexts are kept in a max heap
- Priority is determined by:
  - # sig coefficients coded / total coefficients coded

Reconstruction of Coefficients

- Coefficients are decoded to a certain number of bit planes
  - .101110XXXXX What should X's be?
  - .101110000… < .101110XXXXX < .101110111…
  - .101110100000 is half-way
- Handled the same as SPIHT and GTW
  - if coefficient is still insignificant, do no interpolation
  - if newly significant, add on .38 to scale
  - if significant, add on .5 to scale



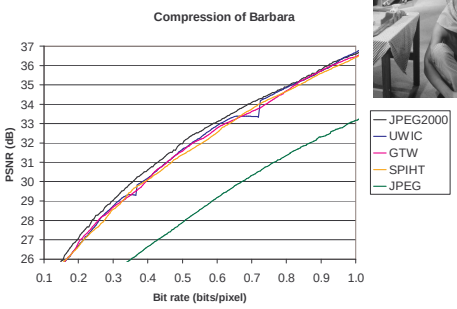
Original Barbara Image

Barbara at .5 bpp (PSNR = 31.68)

Barbara at .25 bpp (PSNR = 27.75)

Barbara at .1 bpp (PSNR = 24.53)

Results



Results

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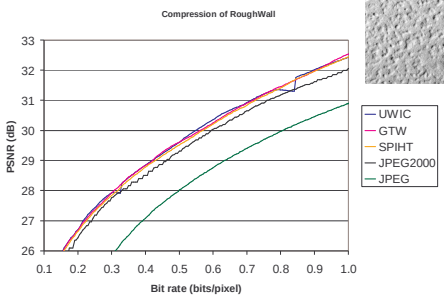

UWIC Notes

- UWIC competitive with JPEG 2000, SPIHT-AC, and GTW.
- Developed in Java from scratch by two undergraduates in 2 months.
- Still a few glitches that have to be worked on.