3D RGB Image Compression For Interactive Applications

Chandrajit Bajaj, Insung Ihm and Sanghun Park

Presented by Brian Krisler

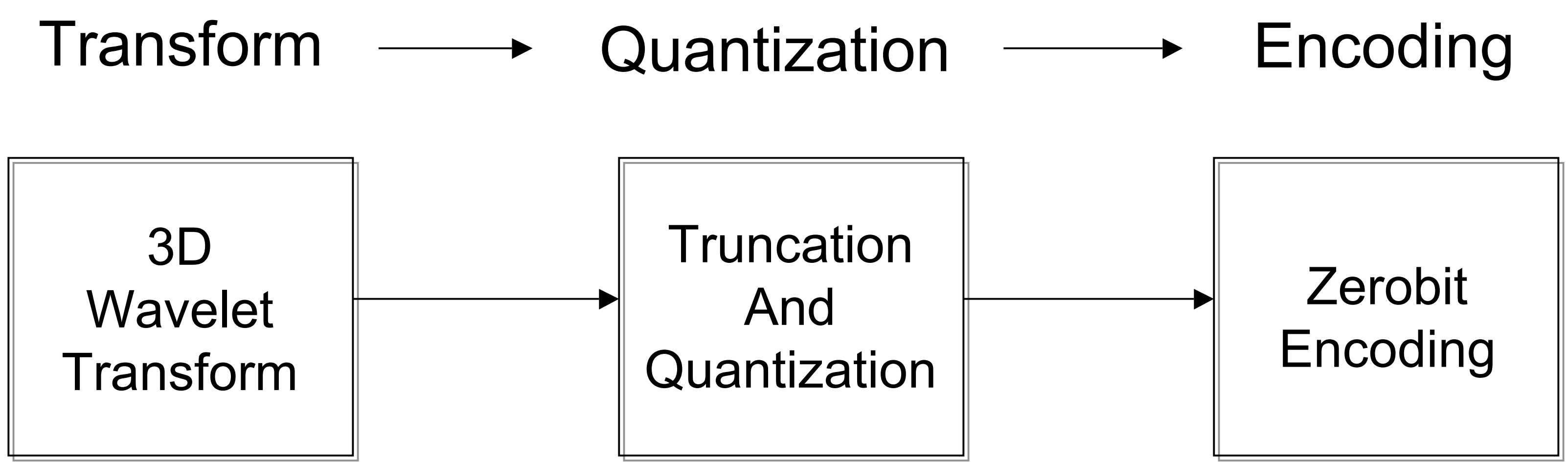
3D Image Compression

Goals for Real-time or Interactive-time Applications

- Multi-resolution representation
- Effective exploitation of data redundancy
- Selective block-wise compression
- Fast decoding for random access
- High compression rate and visual fidelity

Transform Coding Algorithm

Typical Stages



Transform

Three Dimensional Haar Wavelet

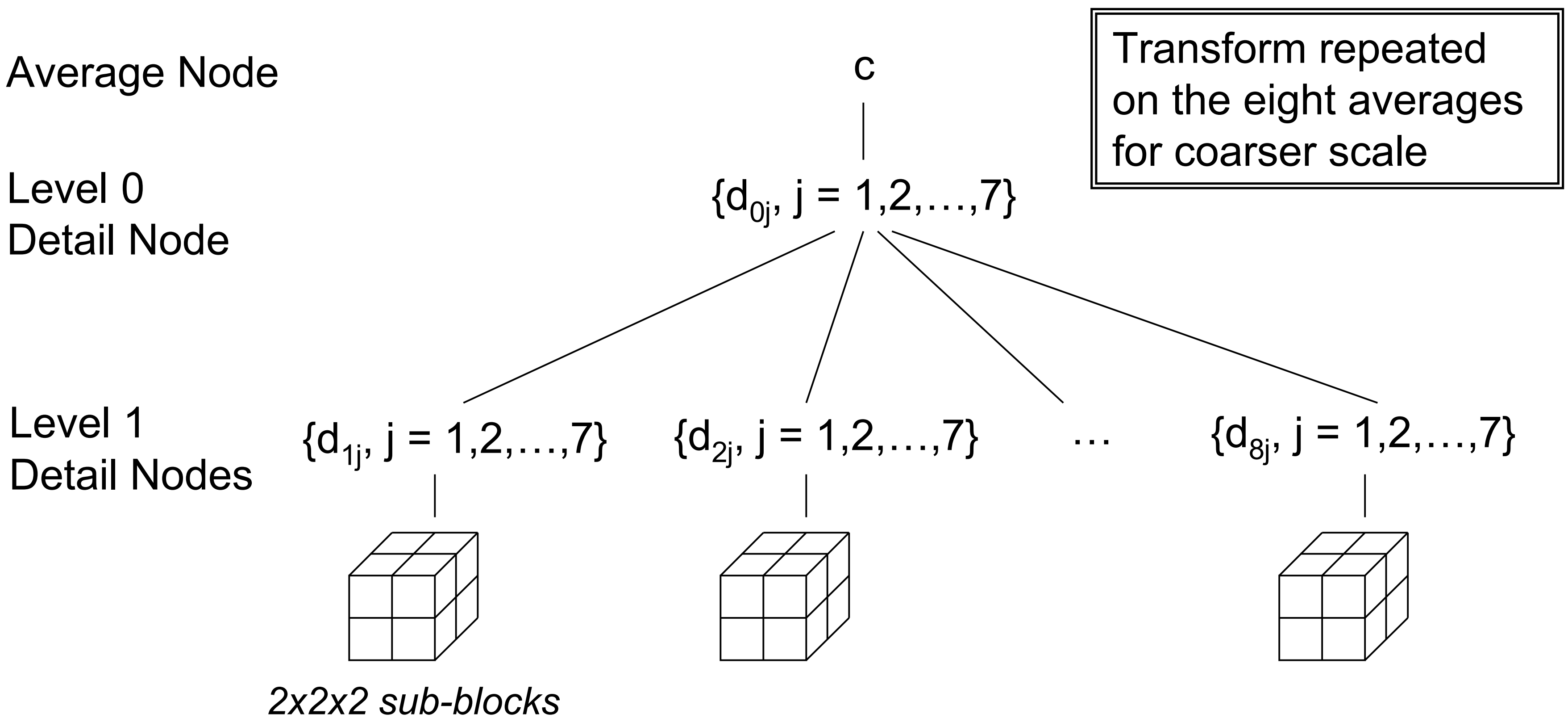
- Averaging and differencing yields average and detail coefficients

8	12	8	24
10	16	-2	-8
13	-3	-2	-8

- Multi-resolution representation
- Tensor products of one dimensional wavelets
- Source reconstructed by inverse transform

Decomposition Tree

Transform of a 4x4x4 cell



Truncation

- Basic wavelet compression theory
  - Select coefficients with largest norm
  - Replace remaining with NULL
- Eliminates 93 - 99% of coefficients
- Determine relative measure of complexity
  - Partition image into 16x16x16 blocks
  - Perform Haar transform on each block
  - Ratio of non-zero coefficients to all coefficients
- Diminishes “blockiness” effect

Quantization

Vector Quantization of Wavelet Coefficients

- Decomposition uses floating point numbers
- Vector quantization used for high compression
  - Two codebooks:
    - Average codebook (0 - 255)
    - Detail codebook (-128 - 127)
  - Contiguous cell regions share codebooks
    - Improves space efficiency
    - Little degradation of reconstructed image quality

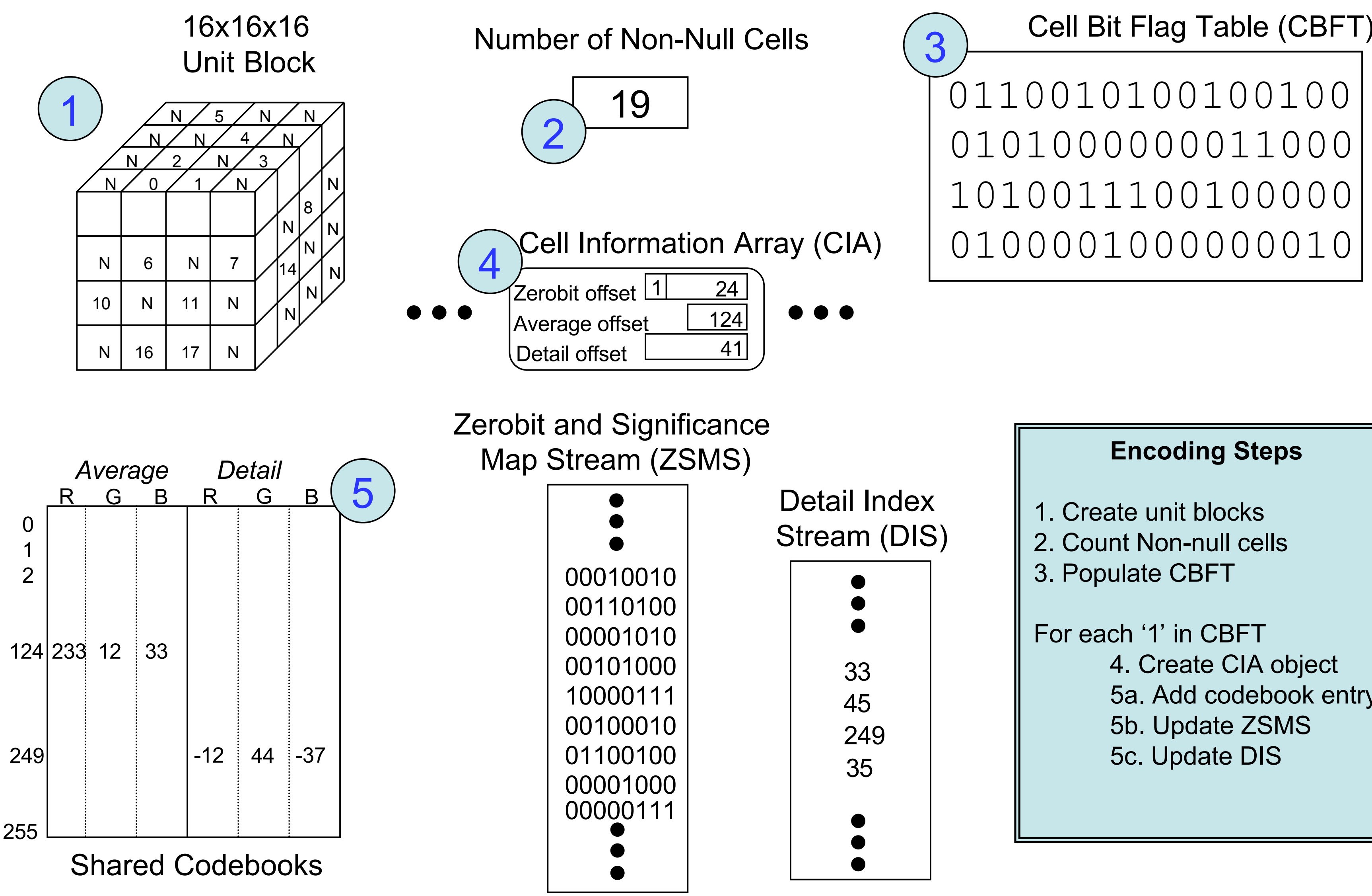
Encoding Process

Overview

- Two-stage significance map
  - Reduces encoding and decoding costs
- Stage Zero
  - Indicate detail nodes null/not null
- Stage One
  - For each non-null detail node
    - Store its seven detail coefficients

Encoding

Zerobit Encoding Process



Encoding Steps

1. Create unit blocks
2. Count Non-null cells
3. Populate CBFT

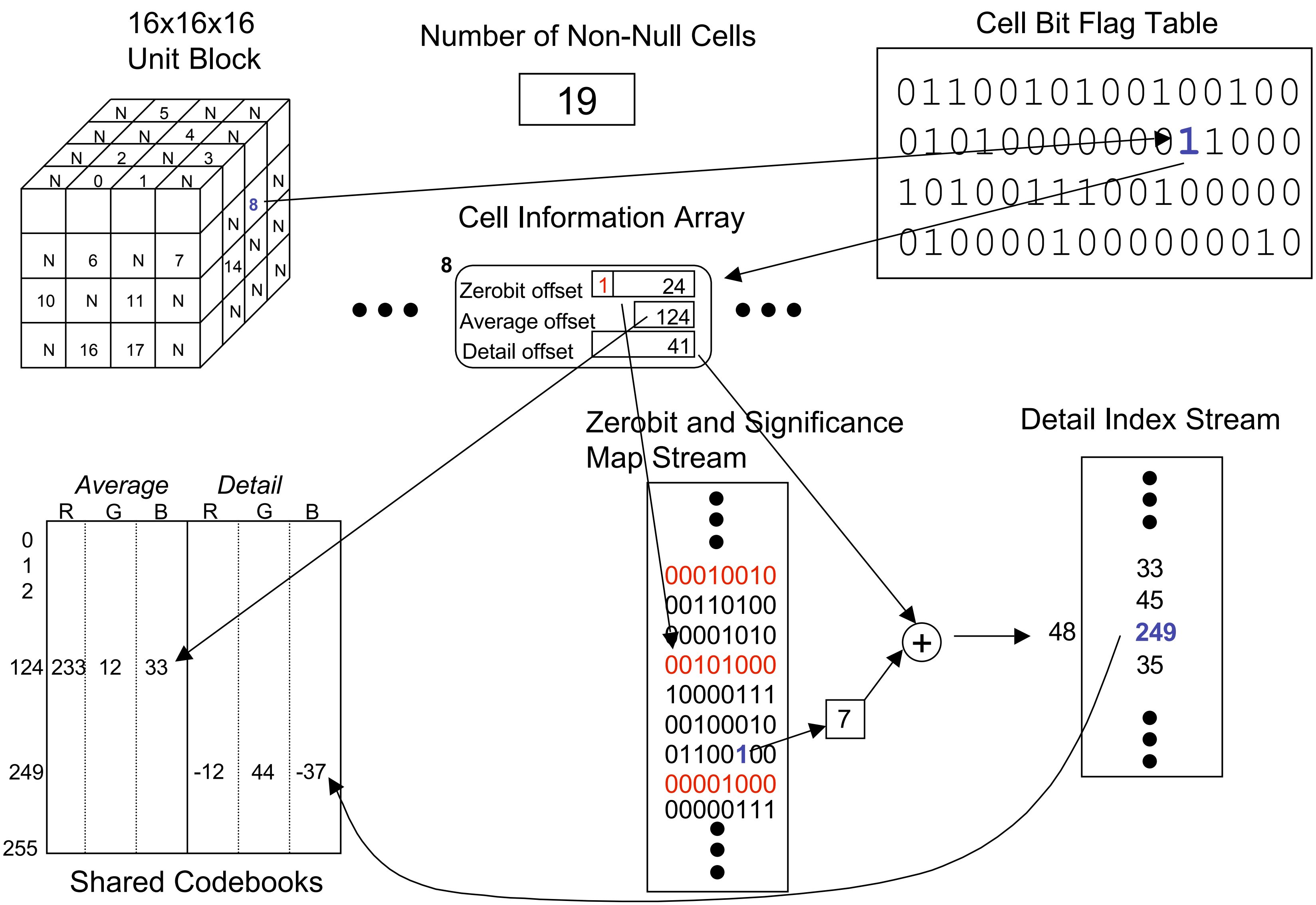
For each ‘1’ in CBFT

- 4. Create CIA object
- 5a. Add codebook entry
- 5b. Update ZSMS
- 5c. Update DIS

Decoding

Zerobit Decoding Process

Retrieve:
detail coefficient d_{55}
of Cell # 8



Experimental Results

Visible Human Cryosection RGB

Compression Ratio
and Visual Fidelity
10-15% Increase

		$\bar{\lambda}$: Target Ratio of Nonzero Coef's			
		2.0%	3.0%	4.0%	5.0%
Size (MB)		80.78	107.90	136.25	164.88
Compression Ratio		81.07	60.69	48.07	39.72
PSNR (dB)	total	32.84	34.27	35.58	36.61
	cropped_abdomen	27.60	28.87	29.77	30.67

Voxel Reconstruction
Time
2.5 - 5.7 times faster

	Uncompressed	$\bar{\lambda}$: Target Ratio of Nonzero Coef's				
			2.0%	3.0%	4.0%	5.0%
voxel_mode 1 (1M Voxels)	1.87	NEW	2.03	2.30	2.47	2.62
		OLD	5.22	5.84	6.31	6.65
voxel_mode 2 (1M Voxels)	1.54	NEW	1.07	1.25	1.39	1.50
		OLD	3.58	3.87	4.08	4.25
plane_mode (1M Planes)	4.32	NEW	3.07	3.55	3.97	4.37
		OLD	N/A	N/A	N/A	N/A
cell_mode (1M Cells)	11.53	NEW	4.34	5.14	5.93	6.80
		OLD	24.72	25.62	26.48	27.14

Experimental Results

Light Field Rendering

Compression Ratio and Visual Fidelity

		Vector Quantization	Zerobit Encoding (Target Ratio $\bar{\lambda}$)			
			2.0%	3.0%	4.0%	5.0%
buddha	Size (MB)	8.81	2.11	2.90	3.63	4.31
	Comp. Ratio	21.79	91.11	66.26	52.89	44.51
	PSNR (dB)	38.00	39.26	41.70	43.63	45.18
dragon	Size (MB)	9.52	2.31	3.15	4.09	5.02
	Comp. Ratio	20.18	83.03	60.87	46.99	38.21
	PSNR (dB)	35.58	31.00	32.17	33.37	34.40

Rendering Time
(Frames per Second)

		Vector Quantization	Zerobit Encoding (Target Ratio $\bar{\lambda}$)			
			2.0%	3.0%	4.0%	5.0%
buddha	st-lerp	9.46	13.60	13.60	13.60	13.60
	$uvst$-lerp	2.68	2.99	2.98	2.98	2.98
dragon	st-lerp	17.55	24.60	24.44	24.20	23.97
	$uvst$-lerp	5.66	5.74	5.71	5.66	5.62

Experimental Results

3D Textures and Objects

Size of Compressed Textures

Object & Texture	Target Ratio $\bar{\lambda}$	Size (KB)	Comp. Ratio
Teapot with Bmarble	3%	188	261.5
	5%	224	219.4
	10%	268	183.4
Dragon with Wood	3%	192	256.0
	5%	232	211.9
	10%	308	159.6
Bunny with Eroded	3%	280	175.5
	5%	356	138.1
	10%	492	99.9
Head with Gmarbpol	3%	332	148.1
	5%	420	117.0
	10%	540	91.0

Rendering Time (per frame)

Object & Texture	Target Ratio $\bar{\lambda}$	NEAR	LINE
Teapot with Bmarble (1,152 faces)	uncomp.	0.13	0.37
	3%	0.14	0.42
	5%	0.15	0.43
	10%	0.16	0.44
Dragon with Wood (12,078 faces)	uncomp.	0.45	0.89
	3%	0.50	0.98
	5%	0.52	1.00
	10%	0.55	1.04
Bunny with Eroded (69,451 faces)	uncomp.	1.39	1.77
	3%	1.56	2.04
	5%	1.60	2.13
	10%	1.66	2.21
Head with Gmarbpol (203,544 faces)	uncomp.	3.68	4.51
	3%	3.89	4.85
	5%	3.94	4.90
	10%	4.00	5.03

Sources

- 3D RGB Image Compression for Interactive Applications
  Chandrajit Bajaj, Insung Ihm and Sanghun Park
  ACM Transactions on Graphics, Vol. 20, No. 1,
  January 2001, Pages 10-38

- Image compression using the Haar wavelet transform
  Colm Mulcahy
  Spelman Science and Math Journal

Backup Slides

Interactive 3D Applications

- Examples
  - Computer Graphics
  - Volumetric Image Scanners (CT & MRI)
  - Global Climate Simulations
- Consist of Very Large Datasets
  - 100’s of MB’s - GB’s