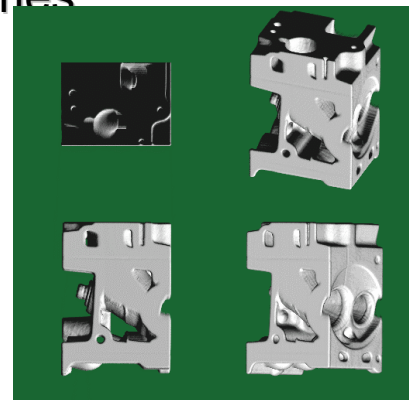
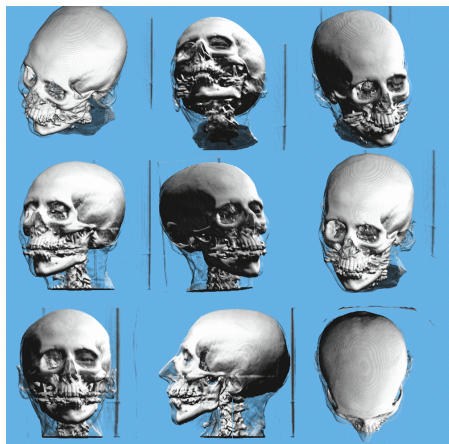




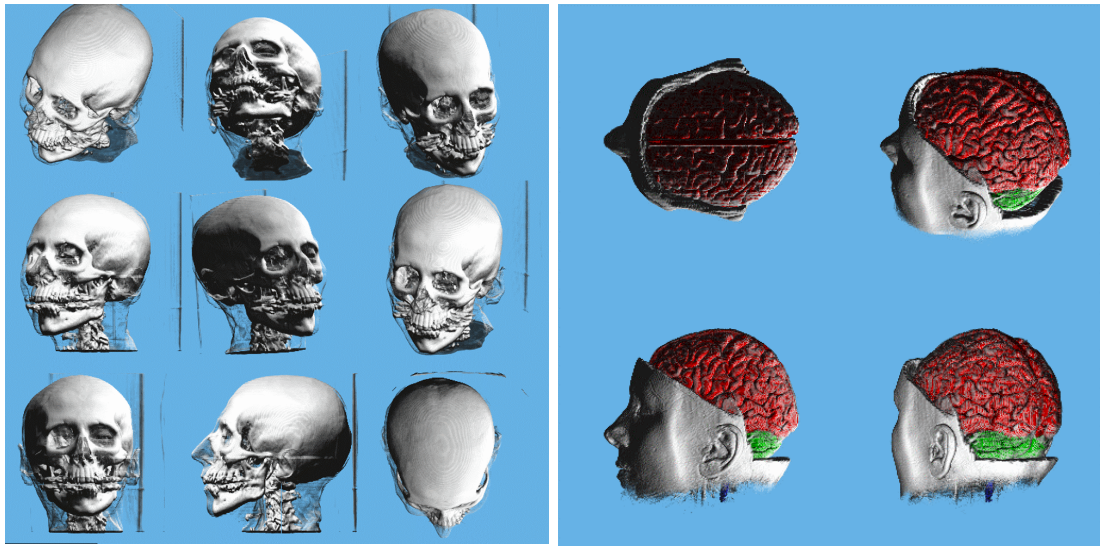
Survey of Parallel Volume Rendering Algorithms

Craig M. Wittenbrink,
craig_wittenbrink@hpl.hp.com
Visual Computing Department
Hewlett-Packard Laboratories



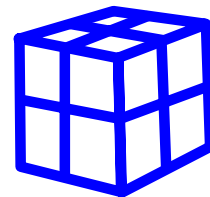
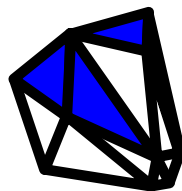
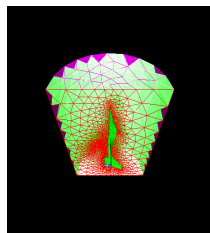
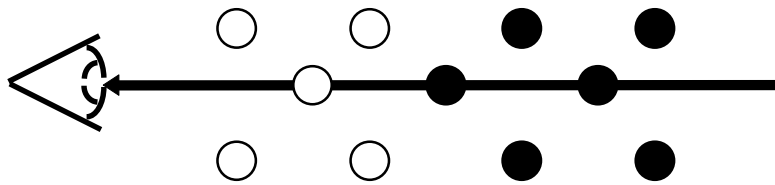
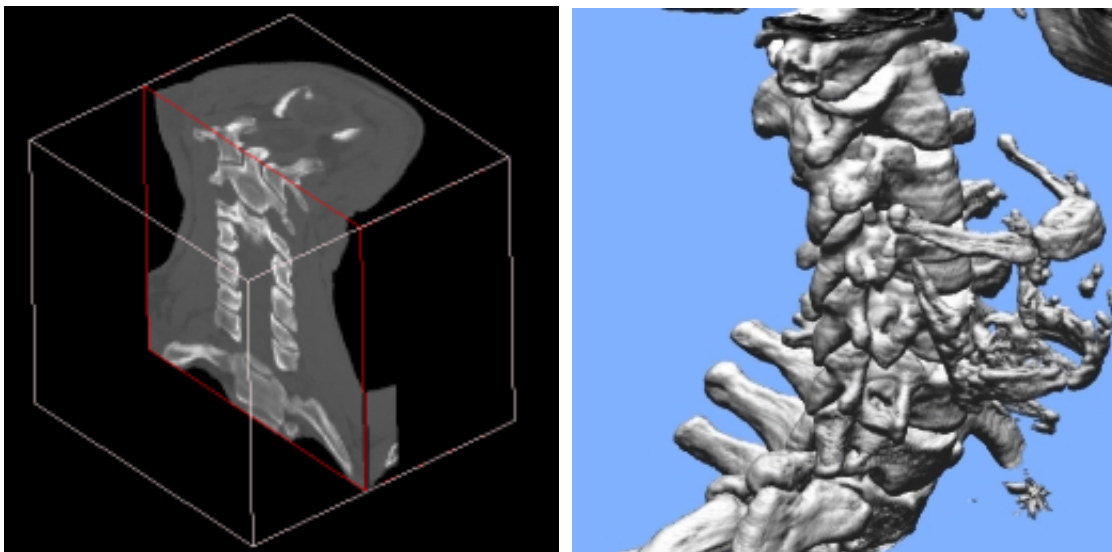
Overview

- Volume Rendering
- Problem, too much research
- Classification
- Example Taxonomy
- Hybrids differentiated
- Conclusions



Volume Rendering

- What it does: Image Slices to 3D Shaded Volumes



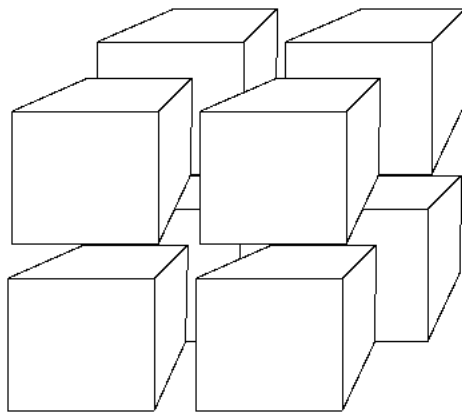
PDPTA'98, July 15, 1998



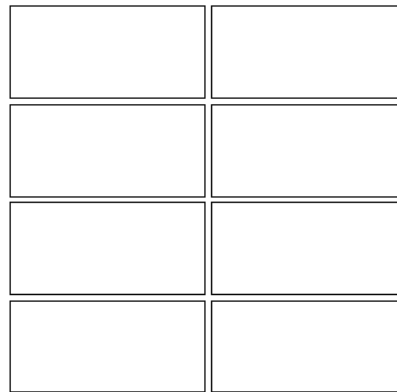
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Volume Rendering: Parallel Theory

- What it is: Volume Rendering is an Optimal Parallel Algorithm $Pt_p = O(n)$



Object Space

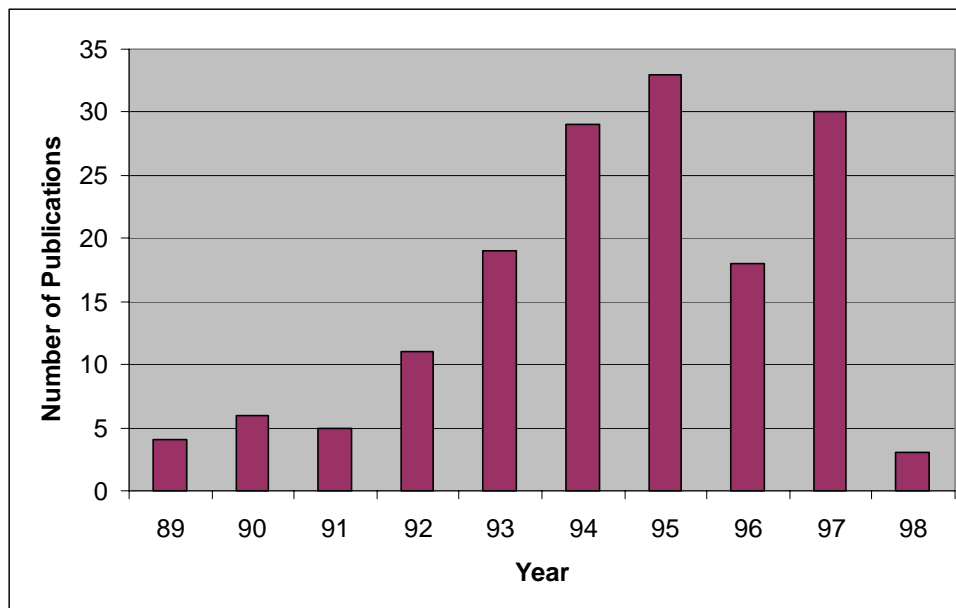


Screen Space



The Problem

- IEEE Inspec Search Results Histogram by year
 - “parallel and (volume rendering or volume visualization)”
 - 100’s of papers



Problem cont

- Field has achieved no consensus
- Replication of results
- No easy dissemination of results
- Incremental improvements?

Solution

- A Survey
 - spell out canonical approaches
 - point way to untried approaches
 - create means for dissemination of results to date

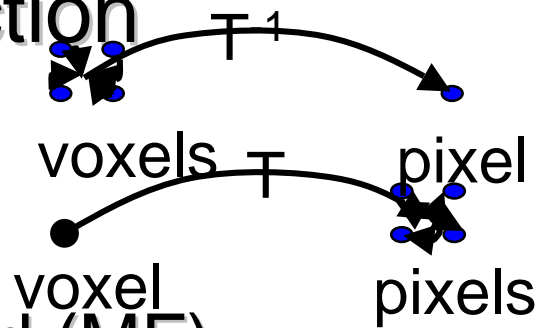
Classification

- Algorithm Control Flow
 - view reconstruction (B, F, MF, \mathcal{S})
 - outer loop data space (O, I)
- Hardware (G, V, PS, PD, D)
- Data characteristics
 - topology (R, C, U)
 - type (scalar, vector)
 - formats
- Visualization method
- Publication specifics

Algorithm Control Flow

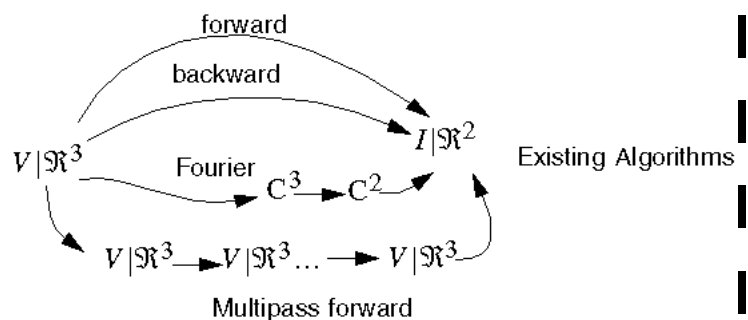
■ View Reconstruction

- backward (B)
- forward (F)
- multipass forward (MF)
- Fourier (\mathcal{F})



■ Outer loop iteration data space

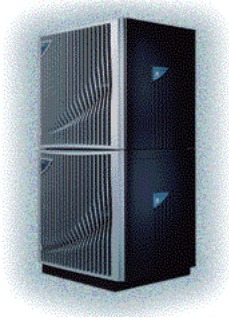
- object (O)
- image (I)



Targeted Hardware

- Graphics (G): PixelFlow
- volume rendering (V): Vizard
- parallel shared address space (PS): Convex-X Class
- parallel distributed address space (PD): IBM SP-2
- distributed (D): Sun render farm for Pixar Toy Story

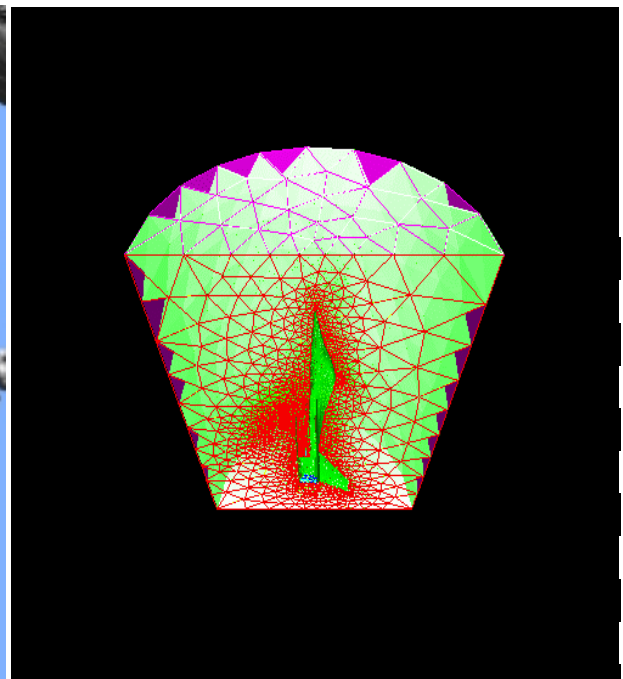
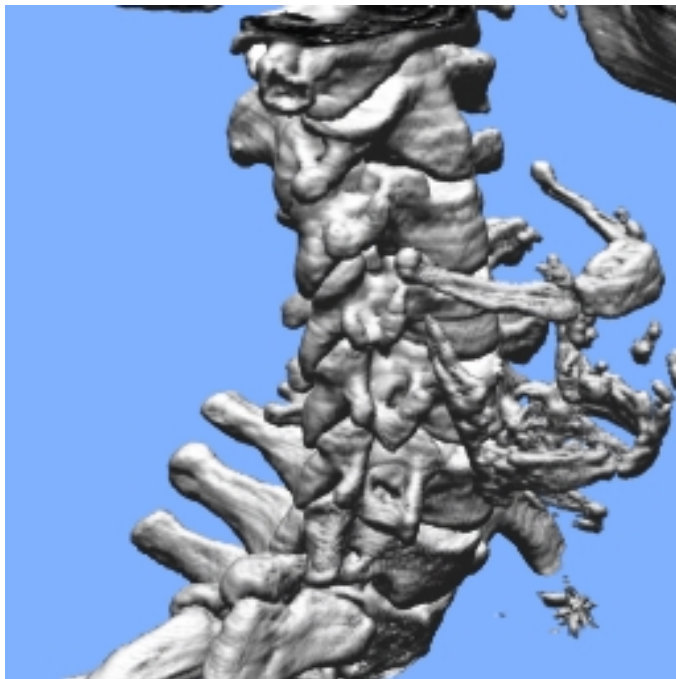
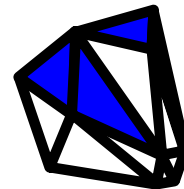
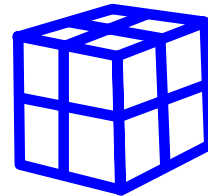
HP X-Class



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Application Data Characteristics

- Rectilinear (R)
- Curvilinear (C)
- Unstructured (U)

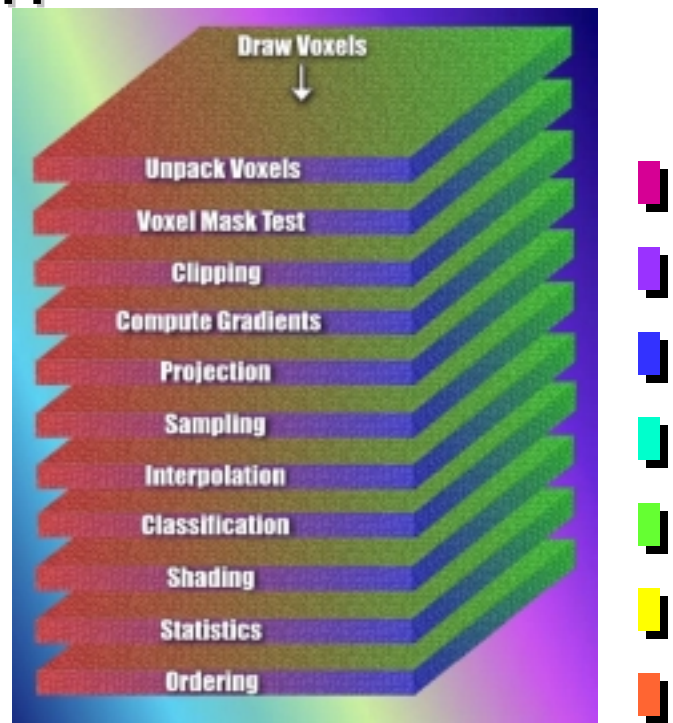


Spiral CT/Vertebrae Nasa Langley Fighter

Visualization Method

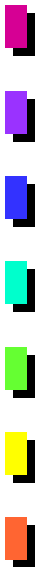
- Shading
- Data Classification
- Transmission model
- Reconstruction
- Gradient

Voxelator OpenGL
Volume Rendering
Proposal



Publication Specifics

- Date published
- Number of processors
- Volume and data sizes
- Prototype or machine implemented
- Asymptotic complexity
- Performance
 - Mvoxels/second
 - scalability



Taxonomy

Prior Work: No differentiation

Processing Order	Object	Image	Hybrid
Algorithm			A,B,C,D

Proposed differentiates all 4

View Reconstruction Outer Loop	Multipass Forward (MF) Object (O)	Multipass Forward (MF) Image (I)	Backward (B) Object (O)	Backward (B) Image (I)
Algorithm	A	D	C	B

Could be debated

A - Lacroute et al. Shear Warp

B - Ma et al. Binary Swap

C - My Permutation Warping

D - Yagel et al./Schroeder et al.

Taxonomy

View	Loop	Graphics (G)	Volume (V)	Parallel shar. add (PS)	Parallel dist. add. (PD)	Dist. (D)
Forward (F)	O	[21]	[7]	[20]	[12] splat	
	I					
Multipass Forward (MF)	O	[1]		[8]A (shear warp)	[15]	
	I		[14]	[16]D(line drawing)		
Backward (B)	O	[17]			[22]C(perm warp)	
	I	[25]	[4]	[13]	[10]B(bin swap)	[3]
Fourier	O					[5]
	I					

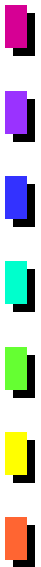
Comprehensive Listing

- Collected over 100 papers in parallel volume rendering
- Complete listing too much
- Need several types of survey
- ACM Computing Surveys?
- Web gathering
 - I need your help! Fill out this simple form, and register your work for posterity's sake ;)

Hybrids are differentiated

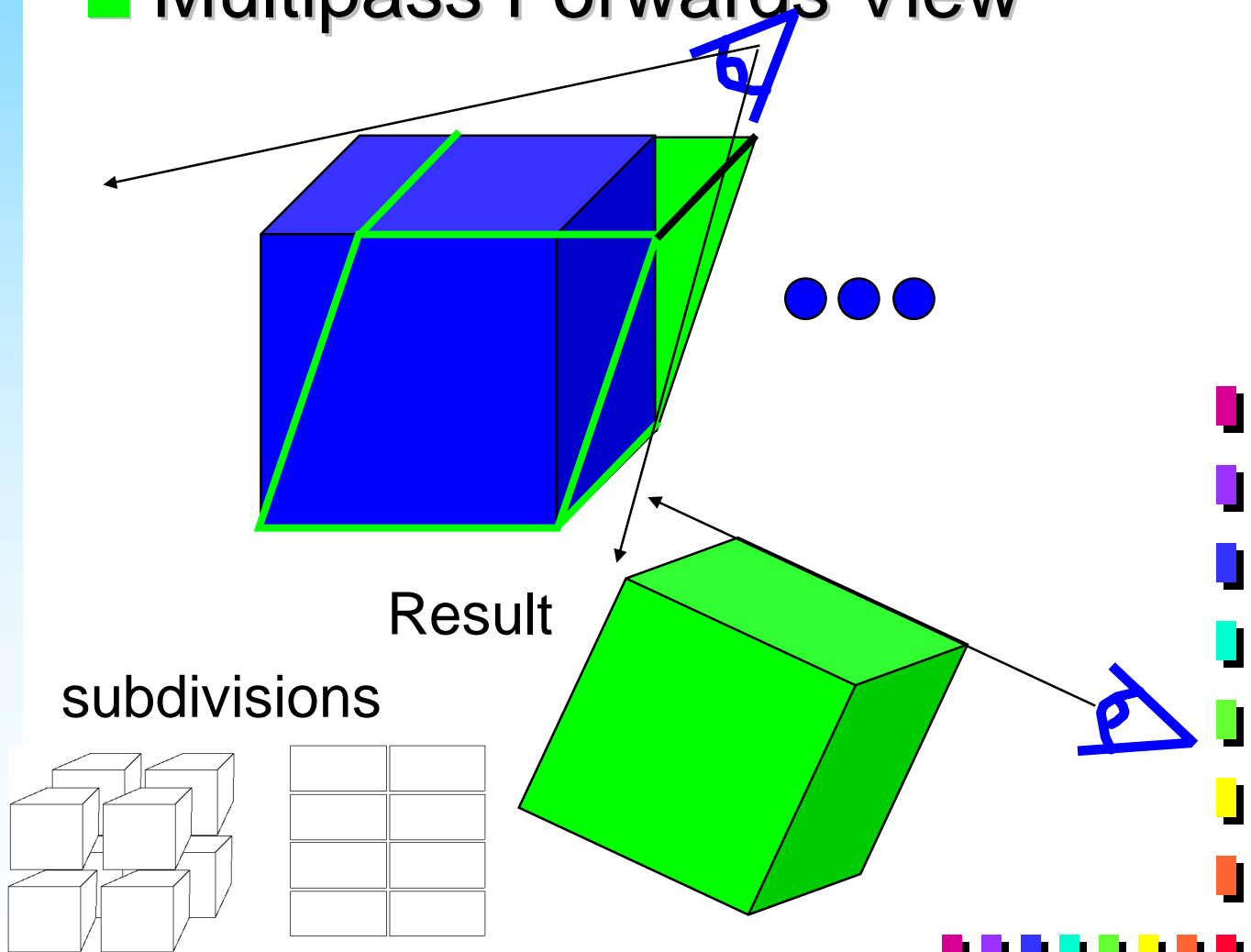
- View:

- Multipass Forwards
 - Lacroute (A)
 - Yagel/Schroeder (D)
- Backwards (ray casting)
 - Ma et al. (B)
- Permutation (ray casting)
 - Wittenbrink et al. (C)



Shear warping (A)

- Object space iteration
- Multipass Forwards View



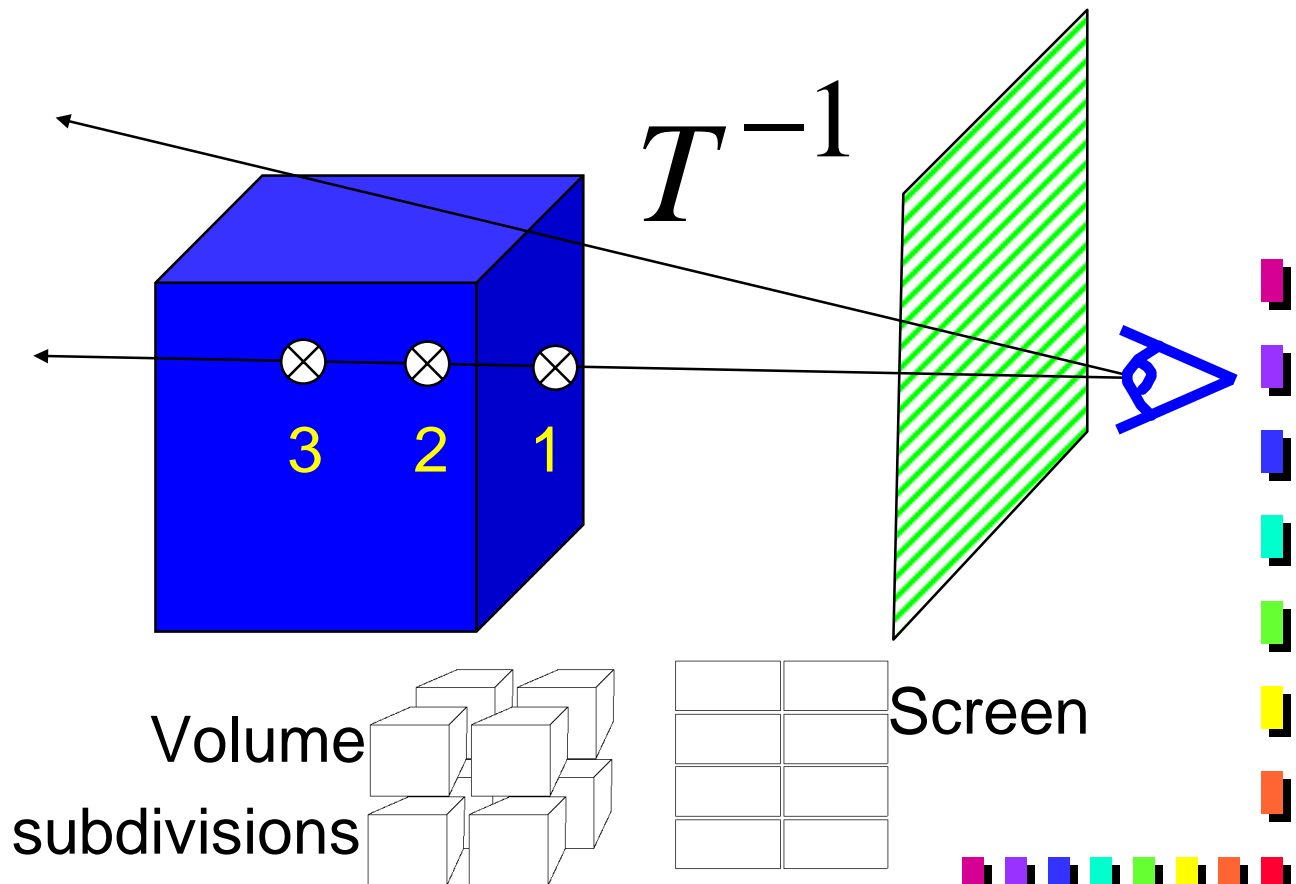
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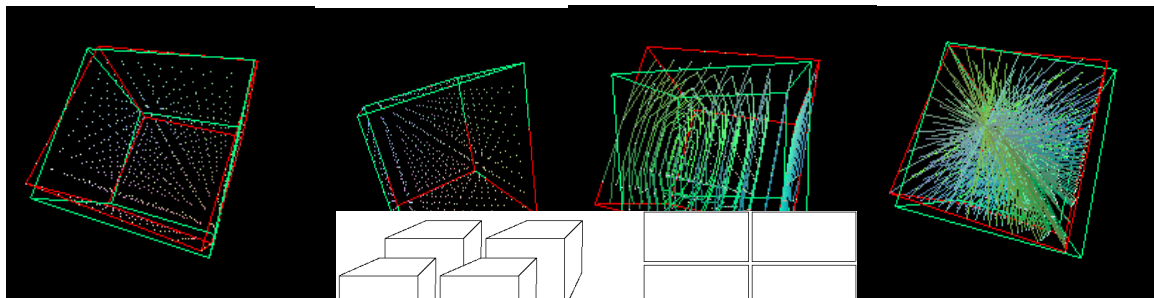
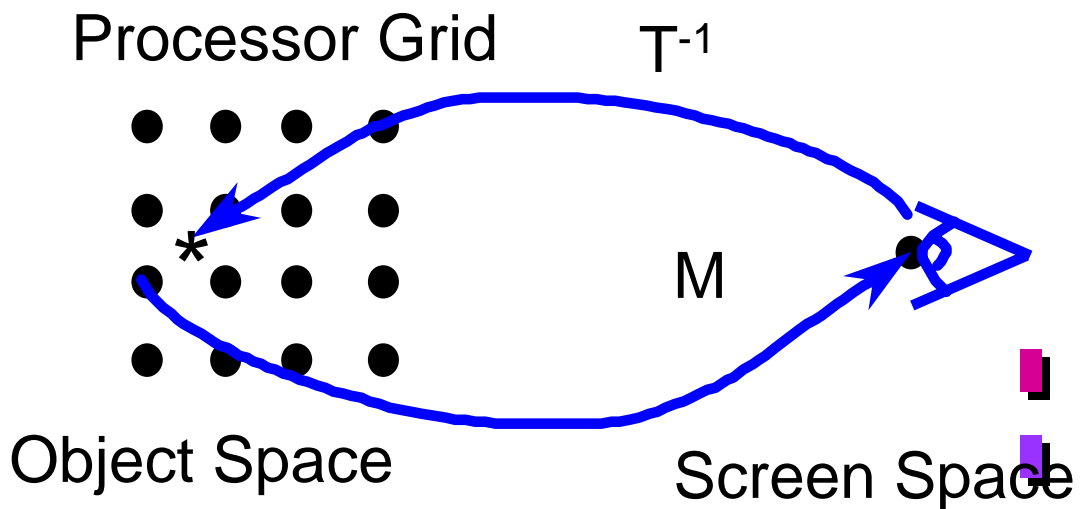
Binary Swap (B)

- Ray casting from eye into volume (binary swap)
- Conceptually simplest

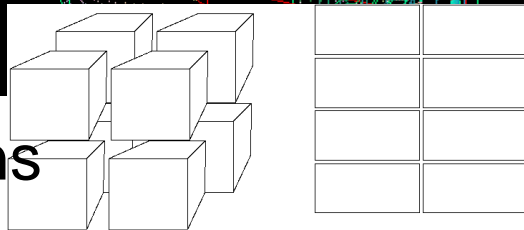


Permutation Warping (C)

- Object space iteration
- backward view transform



subdivisions



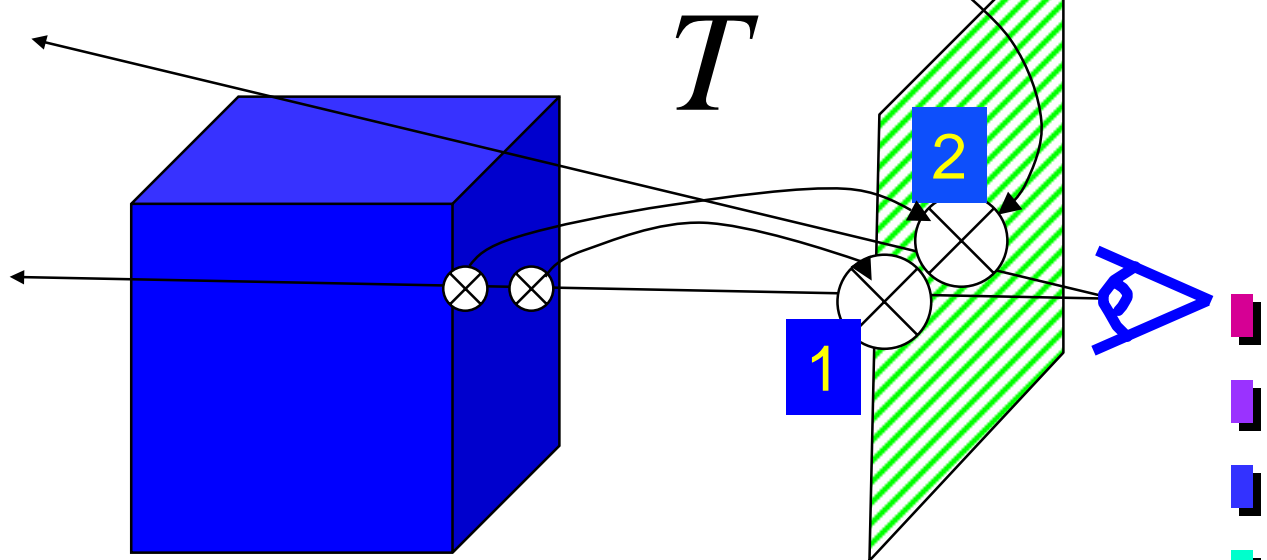
PDPTA'98, July 15, 1998



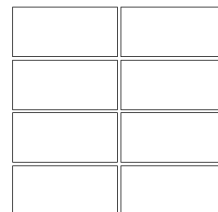
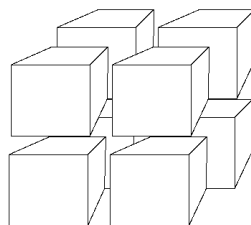
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Line drawing/template based (D)

- Image space iteration splats
- multipass forward view transform



Volume
subdivisions



Screen

Conclusions:

- Volume Rendering
- Parallel Volume Rendering
 - Too much research
- Solution: Classification
 - Algorithm Control Flow
 - View Reconstruction
 - Outer Loop
- Best algorithms not yet discovered
- More Work to be done!

<http://www.cse.ucsc.edu/~craig/pdr.html>

Special Thanks to all