GPU-Based Cell Projection for Large Structured Data Sets

GRAPP

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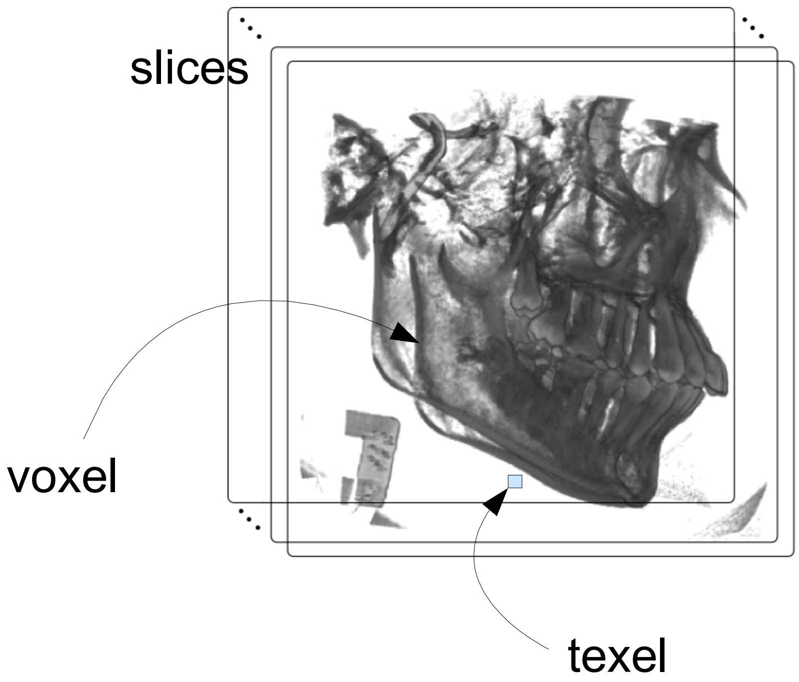
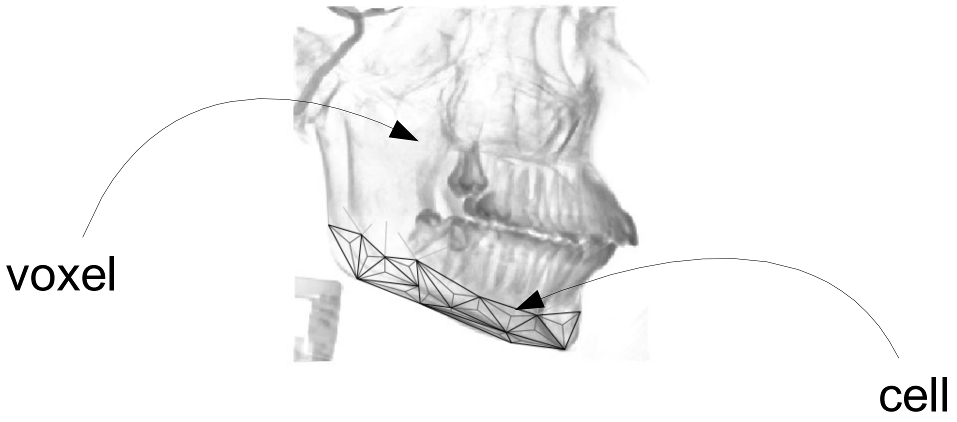
Introduction

- Different approaches for Volume Rendering:
  - 3D Texture



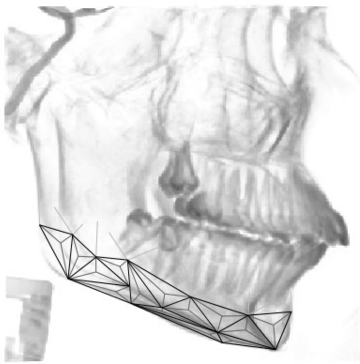
Introduction

- Different approaches for Volume Rendering:
  - 3D Texture
  - Mesh



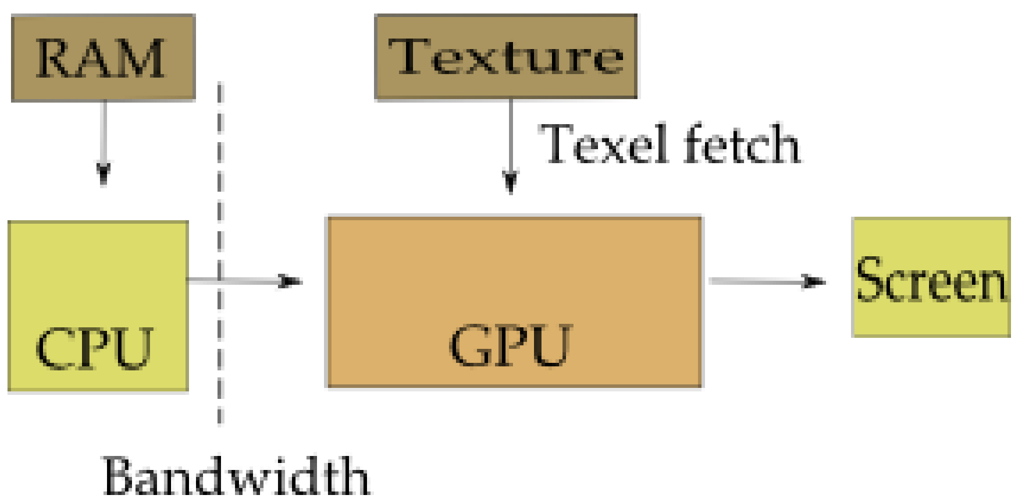
Introduction

- Different approaches for Volume Rendering:
  - 3D Texture → texels/s
  - Mesh → triangles/s



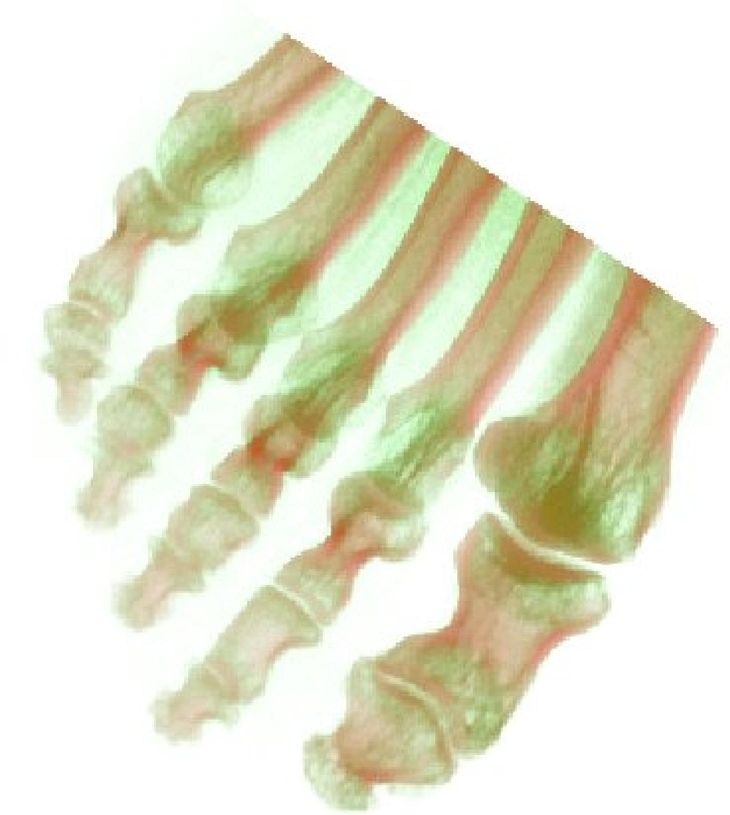
Introduction

- Graphics card features:
  - GPU Memory
  - CPU – GPU bus bandwidth



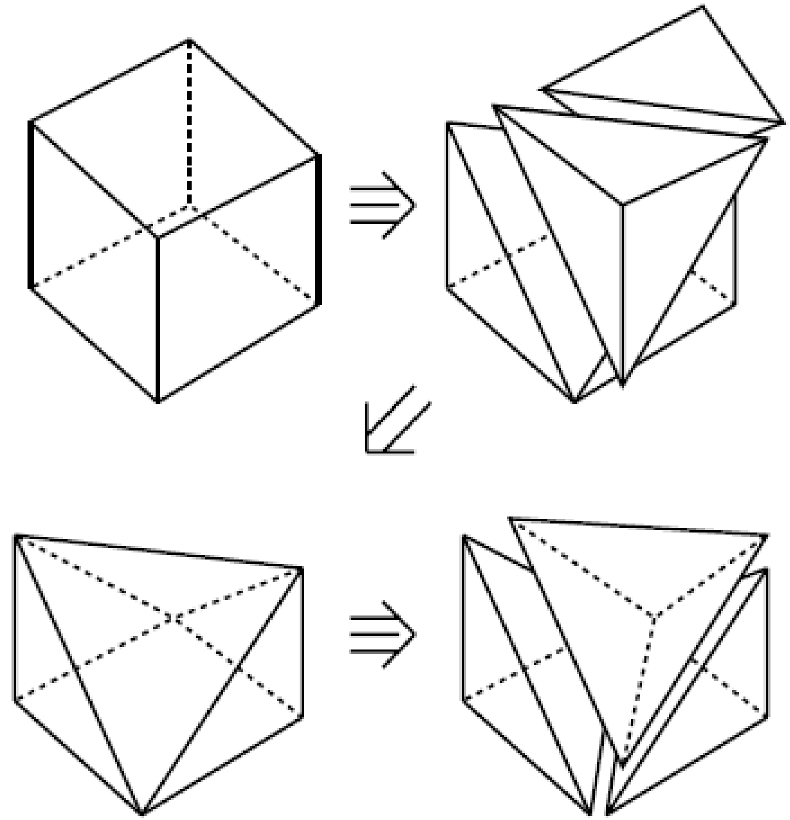
Proposal

- Common solution →
  3D Texture
- Large data sets
- Mesh →
  Cell Projection
- GPU



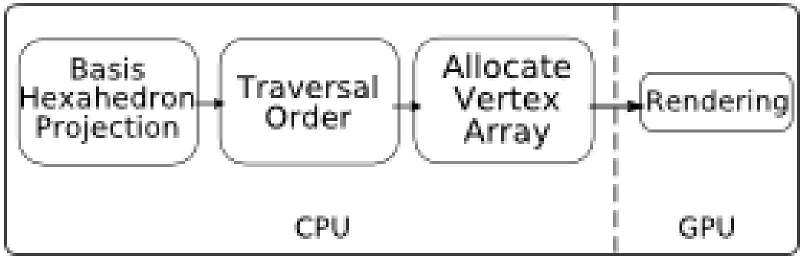
Volunit

- Split 1 hexahedron into 5 tetrahedra
  - 1 hexahedron → 8 voxels → *volunit*



Algorithm Overview

- Project the *volunit* → PT [Shirley and Tuchman 1990]
- Sorting → O(1)
- Create Vertex Array Data Structure → *Volunit*
- Render the volume → GPU



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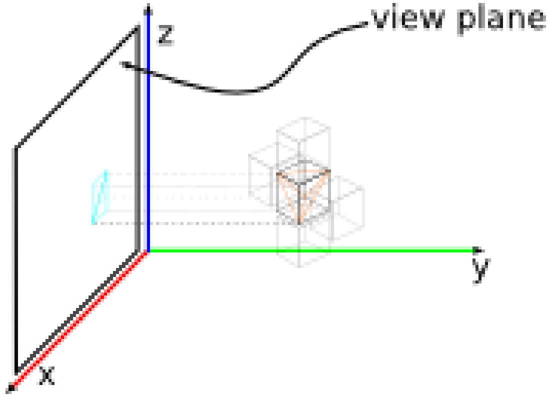
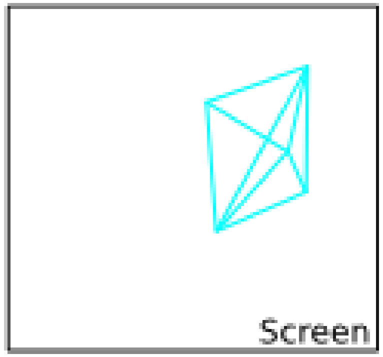
Basis Hexahedron Projection

- Recent implementation of PT [Marroquim et al. 2006]
  - Basis projection class
  - Basis projected vertices coordinates
  - Basis thick vertex coordinates
  - Basis intersection parameters for computing s_f and s_b
  - Basis rendering order





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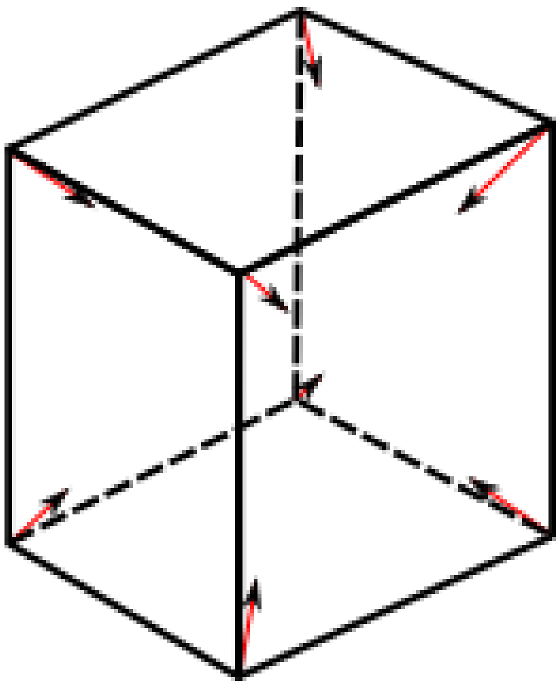
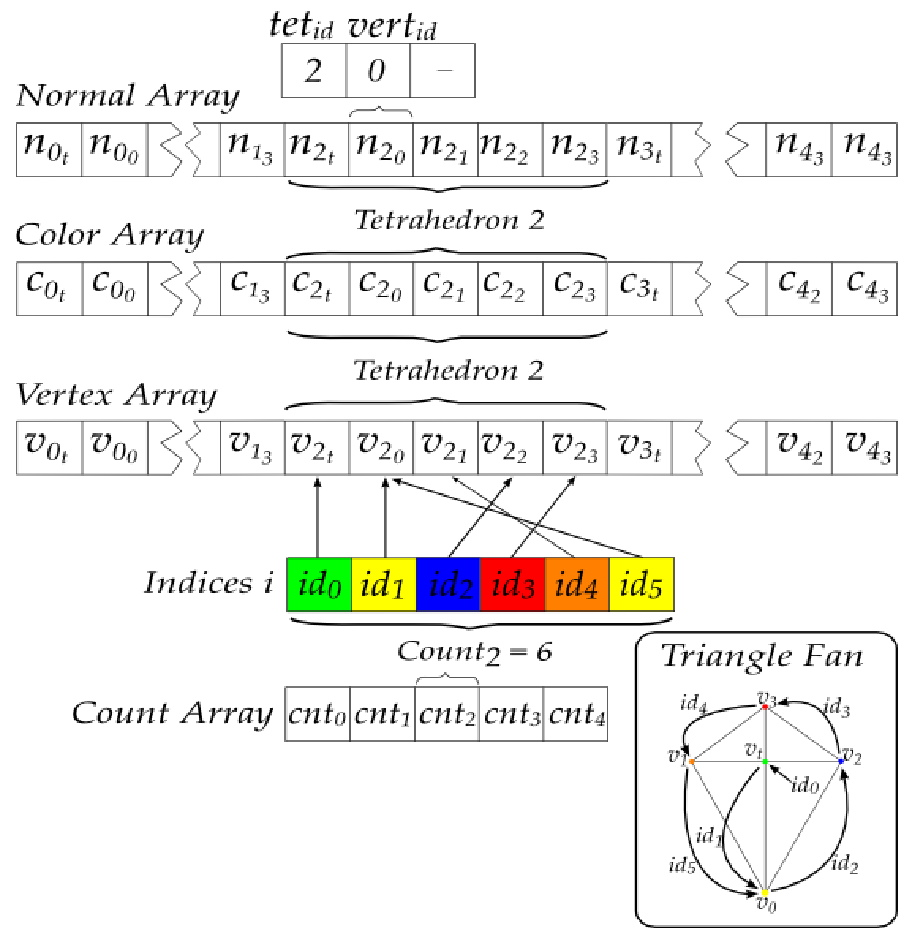
Traversal Order

- Cell Projection worst disadvantage → Sorting
- Regular data → Traversal Order



Allocate Vertex Array

- Optimizing with Vertex Array
- Setup the arrays for each *volunit*



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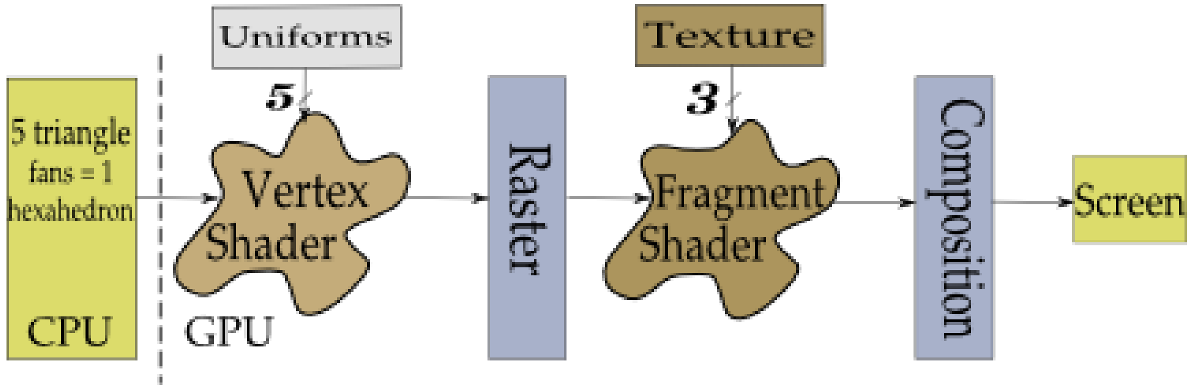
GPU Rendering pipeline

- Each *volunit* is sent as 5 triangle fans
- Basis hexahedron data are stored as uniform variables
- Auxiliary textures are stored on GPU memory



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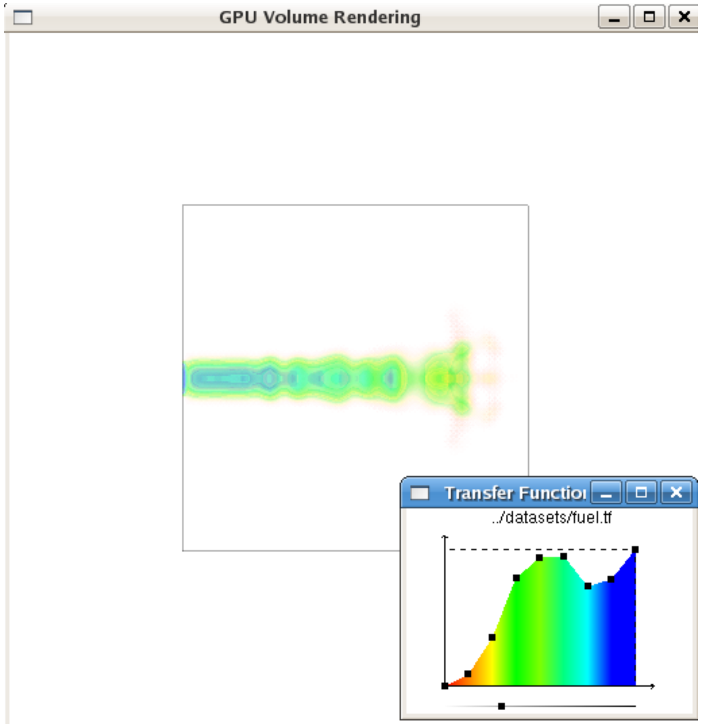
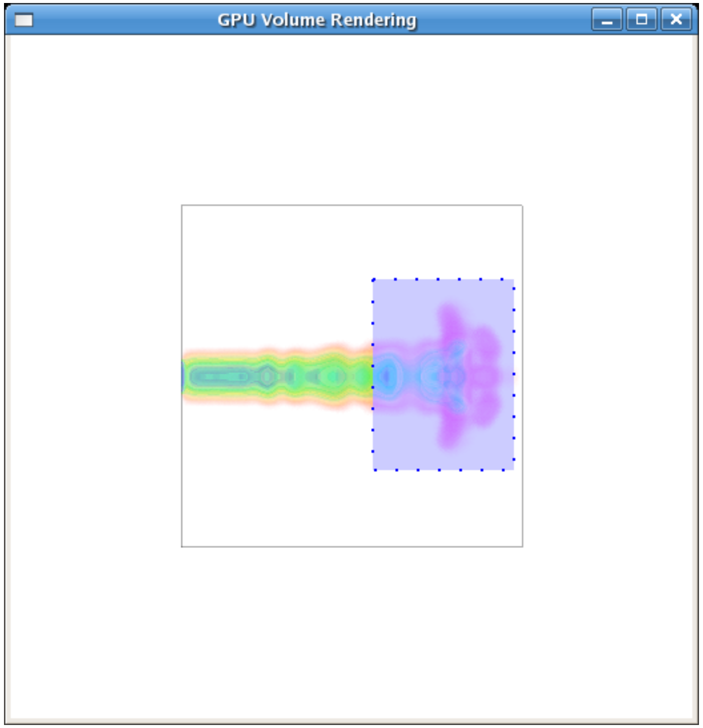
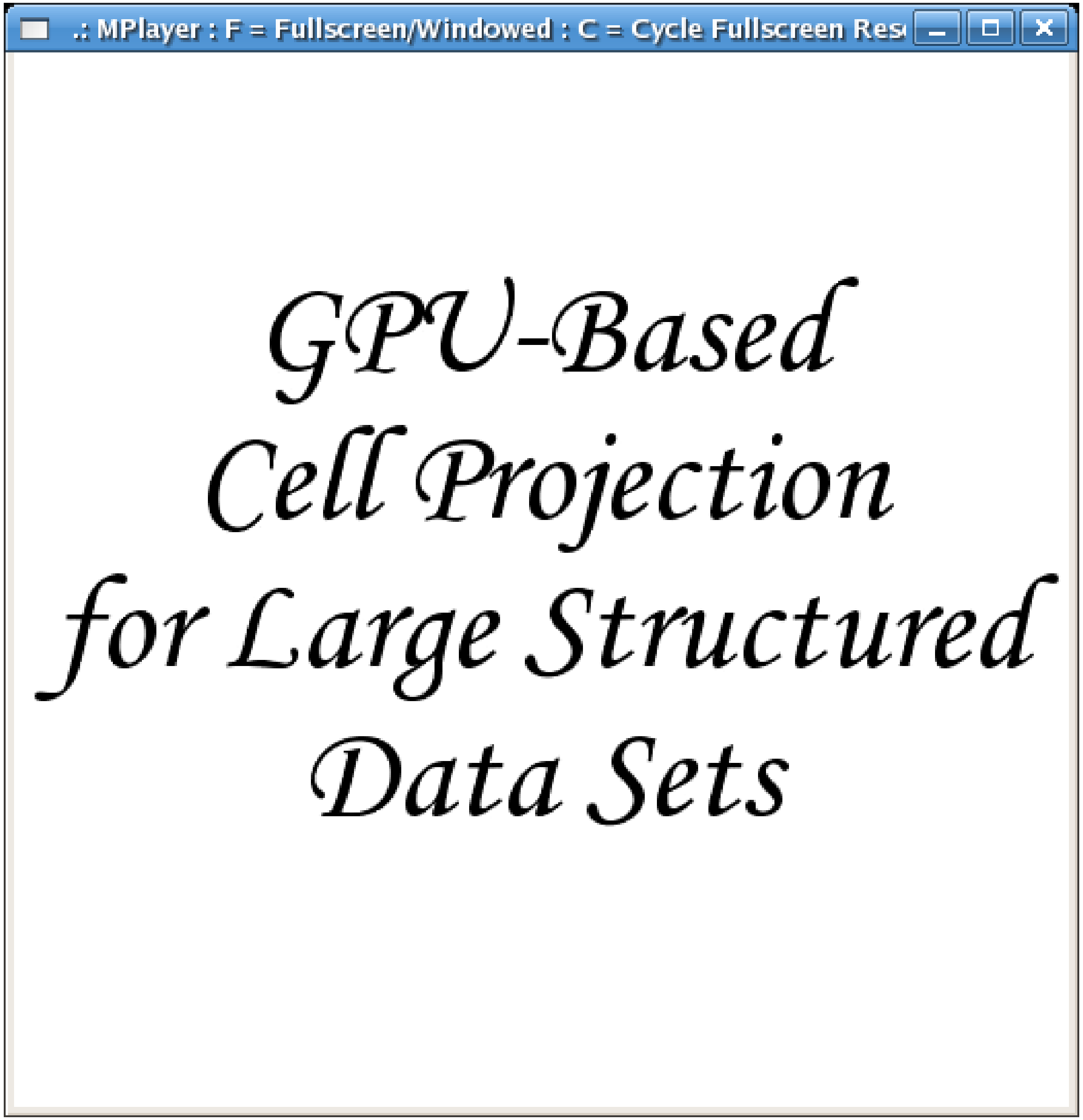
Volume Interaction





- Interactive transfer function editing
- Volume clipping

Video



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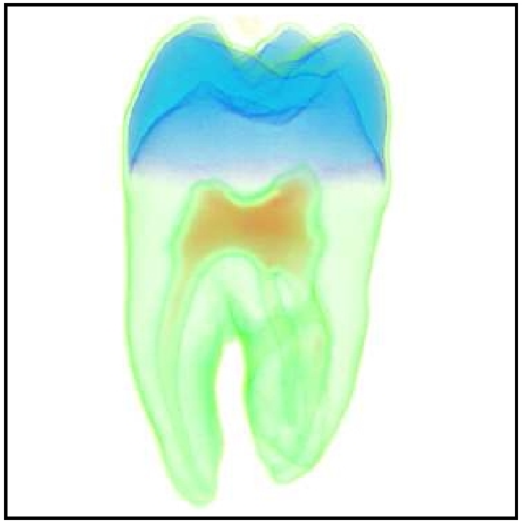
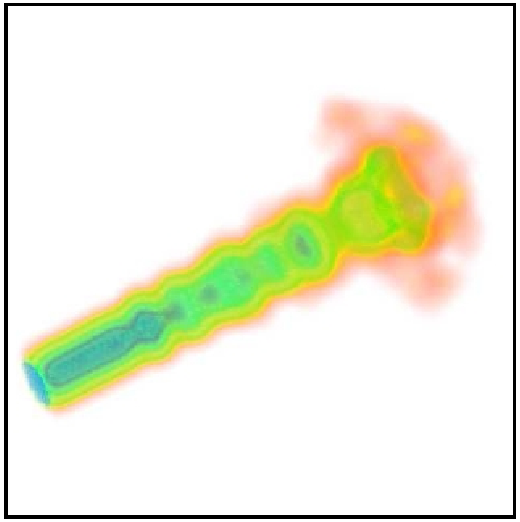
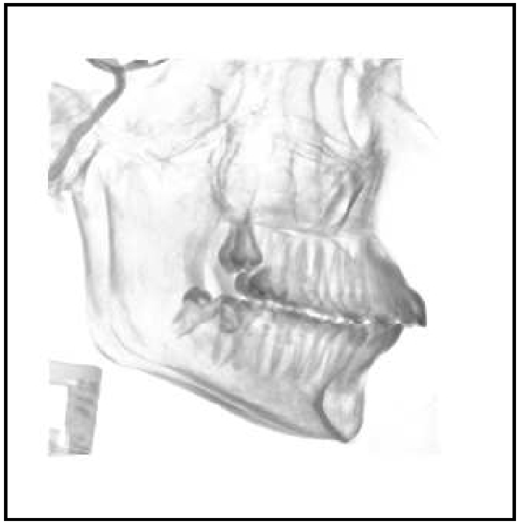
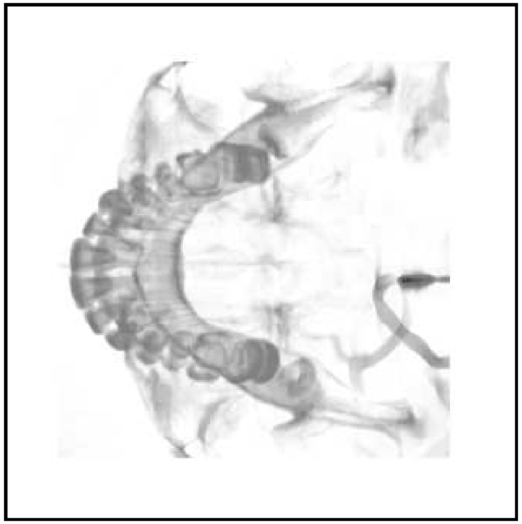
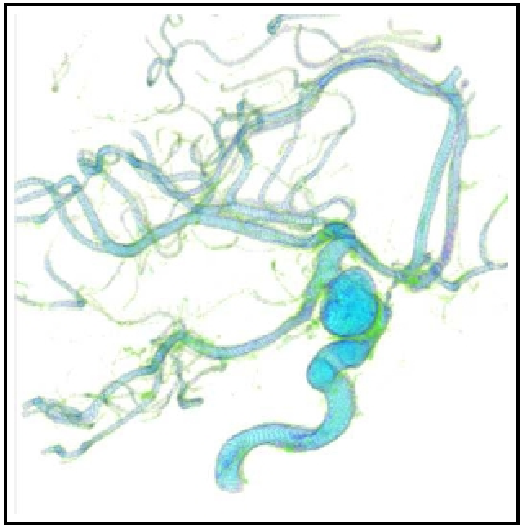
Results

Results

- High tetrahedra/s performance
- No GPU memory used
- More time spent on GPU than CPU

Table 1: Average frames and tetrahedra per second.

Data set	*# Verts*	*# Tet*	*fps*	*M tet/s*
Fuel	262 K	1.2 M	70.78	88.5/5.99
ToothC	1 M	5 M	1.22	13.1/6.30
Tooth	10 M	52 M	0.24	12.7/6.61
Foot	16 M	83 M	0.81	67.7/6.23
Skull	16 M	83 M	0.61	51.7/6.25
Aneurism	16 M	83 M	2.42	201/5.35

Table 2: Setup and render times.

Data set	*Setup*	*Render*	*% Total*
Fuel	0.005 s	0.009 s	64.28 %
Tooth	1.377 s	6.484 s	82.47 %
Foot	4.556 s	9.074 s	66.57 %
Skull	4.606 s	8.593 s	65.10 %
Aneurism	0.199 s	0.210 s	51.34 %

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Conclusions

- High tetrahedra/s performance
  - ↓ Lower than 3D Texture
- No GPU memory used
  - ↑ Larger data sets than 3D Texture
- More time spent on GPU than CPU
  - ↑ closer to the theoretical limit [Roettger and Ertl 2003]

Future Works

- Rendering less primitives
  - Join the 5 tetrahedra (~20 triangles) projected shape in less triangles
  - Project the hexahedron
- Enhance the visualization with a Phong lighting model

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Thank you!