High Quality Real-Time Volume Rendering for Time-Dependent Medical Data

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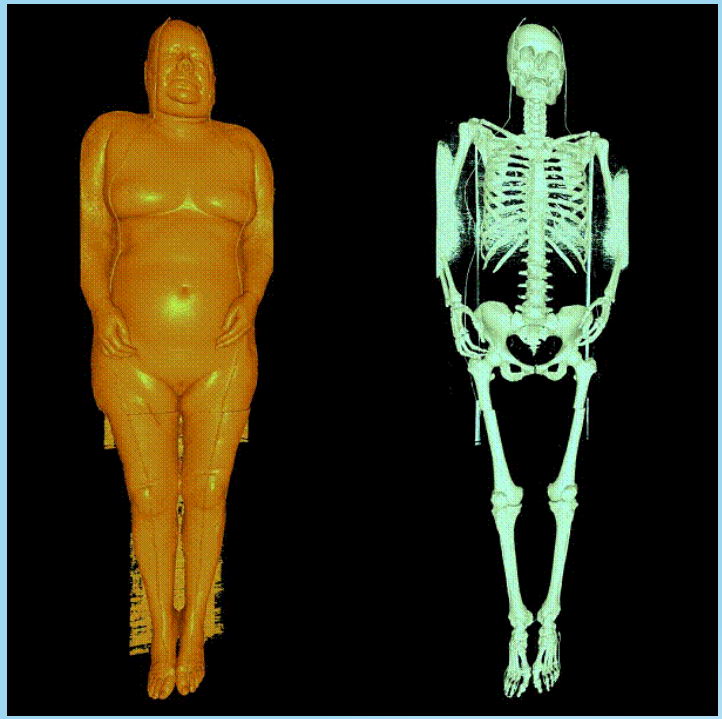
Motivation

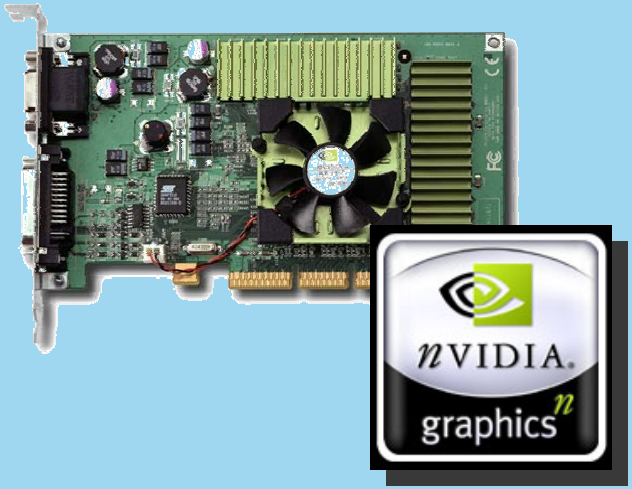
- Medical Data Acquisition
  - **Large datasets**
    - e.g. Visible Human (512^2x1877)
  - **Time resolved datasets**
    - e.g. Heart (512^2x202x10 steps)
  - Used for
    - Diagnosis
    - Pre- / Intra-operative planning
    - Computer Aided Surgery
    - ...

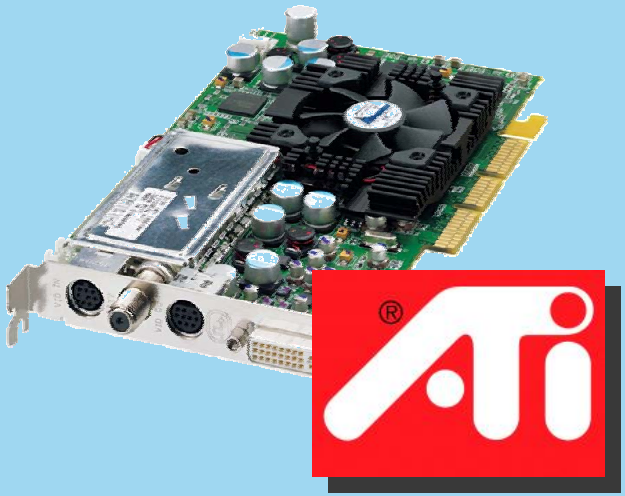


Courtesy University of Utah

→ Need for **interactive** display techniques
- Amenable to gigabyte datasets *and* high quality

Consumer Class Graphics Hardware

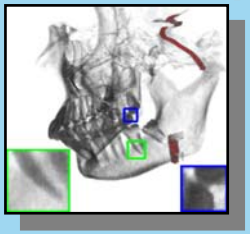




- Cheap
  - Less than 600€
- Fast
  - Processor (25+ GFlops)
  - Memory bandwidth (35+ GB/s)
- Flexible
  - programmable
  - Floating point precision
  - 16bit Texture formats
- 2x performance each year
- **Natural choice**

Drawbacks

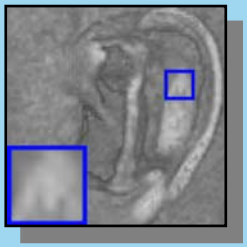
- Low graphics memory – usually 256MB



Compression Domain Volume Rendering

[Schneider, Westermann 2003]

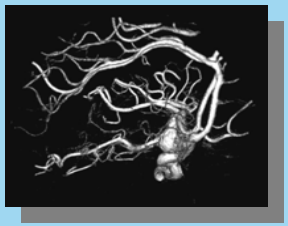
- Slice artifacts of texture-based approaches



On-Chip Ray-casting

[Krüger, Westermann 2003]

- High computational burden

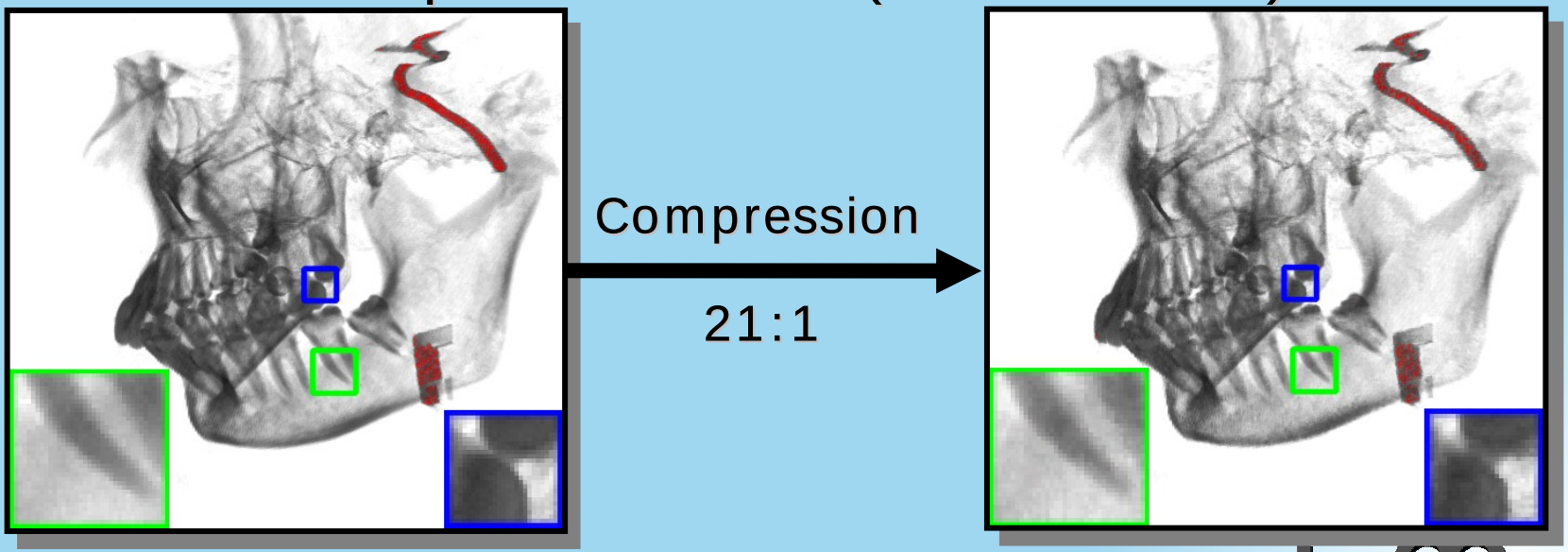


Acceleration Techniques for GPU-based Volume Rendering

[Krüger, Westermann 2003]

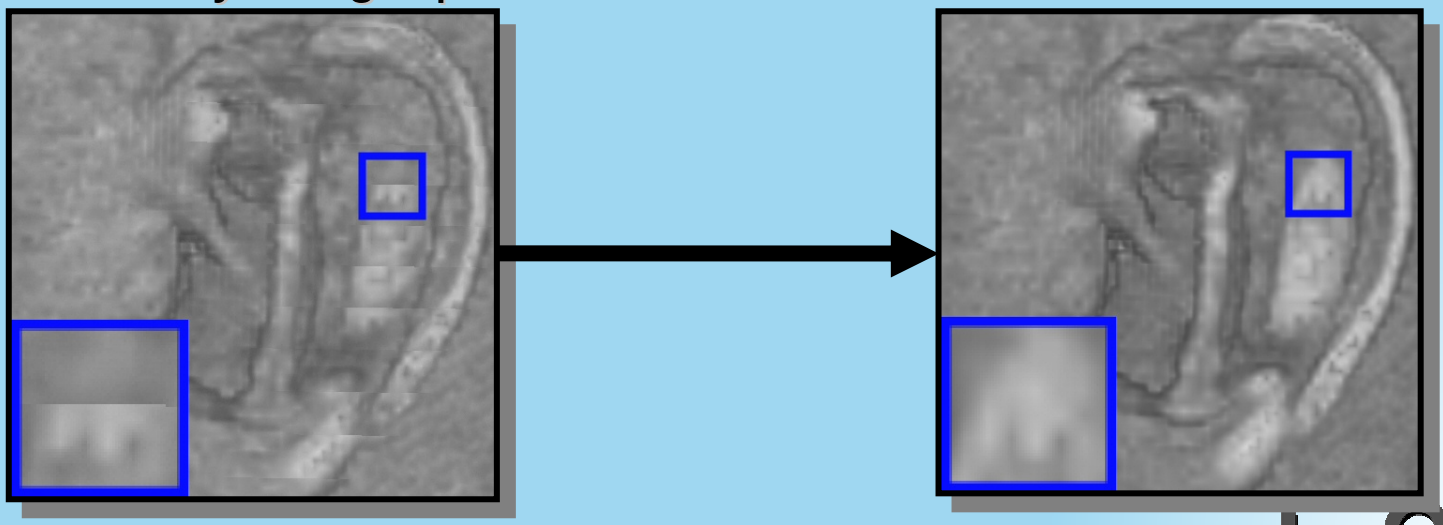
Compression

- Lossy compression on CPU
  - High quality (16bit precision) off-line processing
- Real-time reconstruction on the GPU
  - Significantly saving graphics memory
- Flexible compression ratio (20:1 ... 64:1)



Ray-Casting

- Texture based volume rendering
  - deFacto standard for interactive applications
  - Very fast, but artifacts
- Ray-Casting
  - Expensive, but very high quality
  - Directly on graphics hardware



Acceleration Techniques

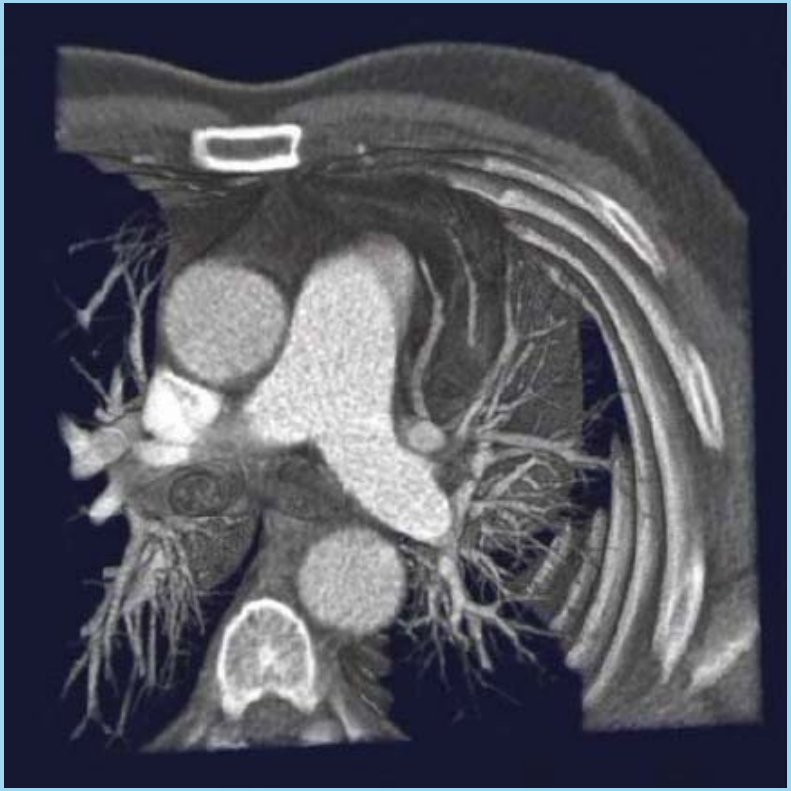
- Empty space skipping
  - Most of the volume may be transparent
- Early ray termination
  - Large parts of volume may be occluded / totally opaque
- Combine both approaches
  - Retains high quality, achieves interactivity

Conclusion

- Compression mandatory
  - Fast preview
  - Datasets otherwise not tractable
- Ray-casting for high quality images
  - Avoids slice artifacts
  - Possible on current graphics hardware
- Acceleration techniques
  - Great speed-up
  - Enable interactive framerates (15+ fps)

Movie / Discussion

Video available from our webpage



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