Computer Graphics

- Outlook -

Hendrik Lensch

Overview

- **Last Lectures**
  - Current trends
  - Current work in AG4 – MPI
  - Current work at UdS

- **Exam**
  - Monday, 18th
    - **please be there at 8:00 sharp**
    - starts at 8:15 will end at 10:00.
  - bring a ruler
  - no other devices!

Highlight you should not have missed!

a non-exclusive list of relevant topics of this lecture

Topics (1)

- **ray tracing vs rasterization**
- **recursive ray tracing**
- **ray surface intersections**
- **spatial acceleration structures (dynamics)**
- **shading, reflection, refraction, BRDF, …**
- **radiometry**
- **rendering equation**
- **texture mapping (mip-maps, …)**
- **sampling theory**
- **antialiasing**
- **HDR, contrast, tonemapping**
- **transformations!**
- **rasterization (Bresenham, polygons)**

Topics (2)

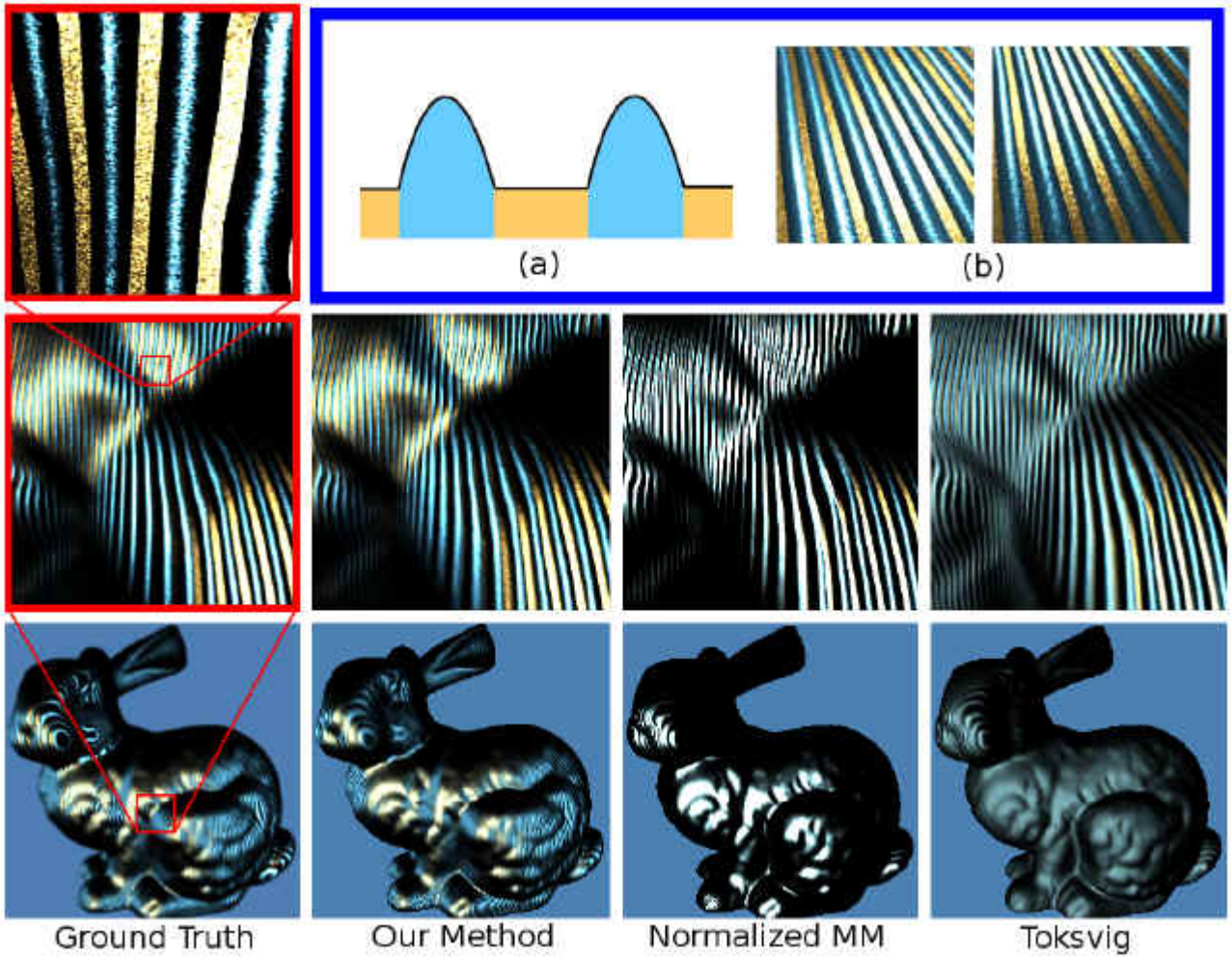
- **OpenGL, Cg (basics)**
- **plenoptic function, light fields, panoramas**
- **splines (evaluation)**
- **volume rendering**

Lots of topics not touched in this lecture

(have a look at the SIGGRAPH proceedings)

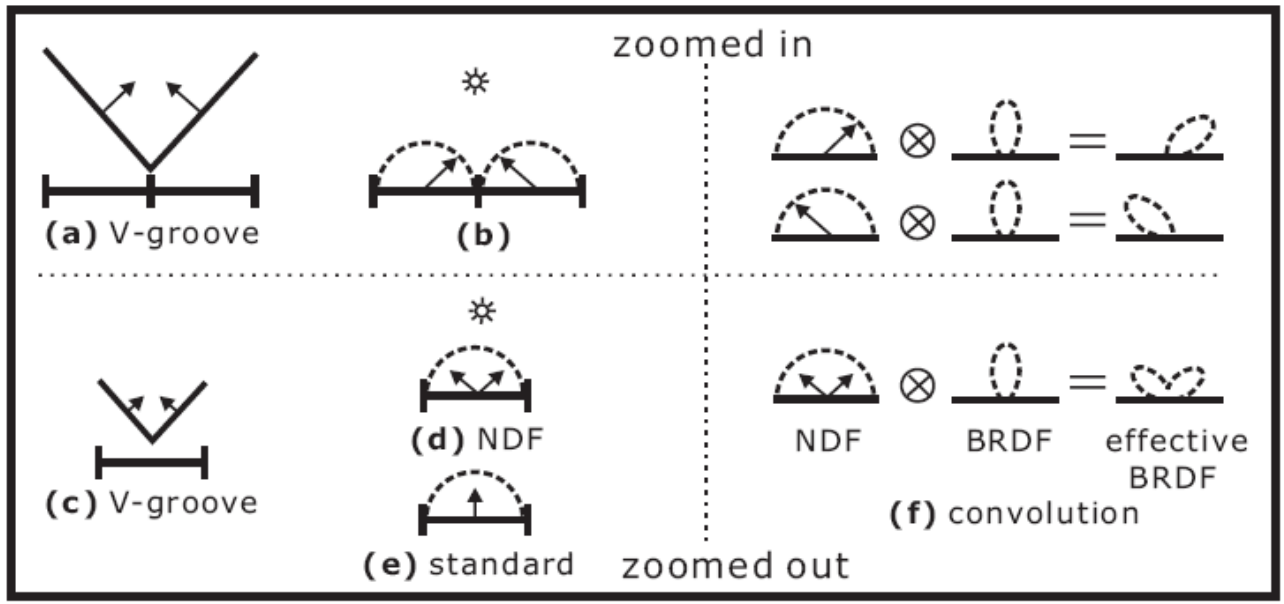
Level of Detail in Shading

- **Frequency Domain Normal Map Filtering [Han et al. – SIGGRAPH 2007]**
- **rendering of surface detail depends on viewing distance**

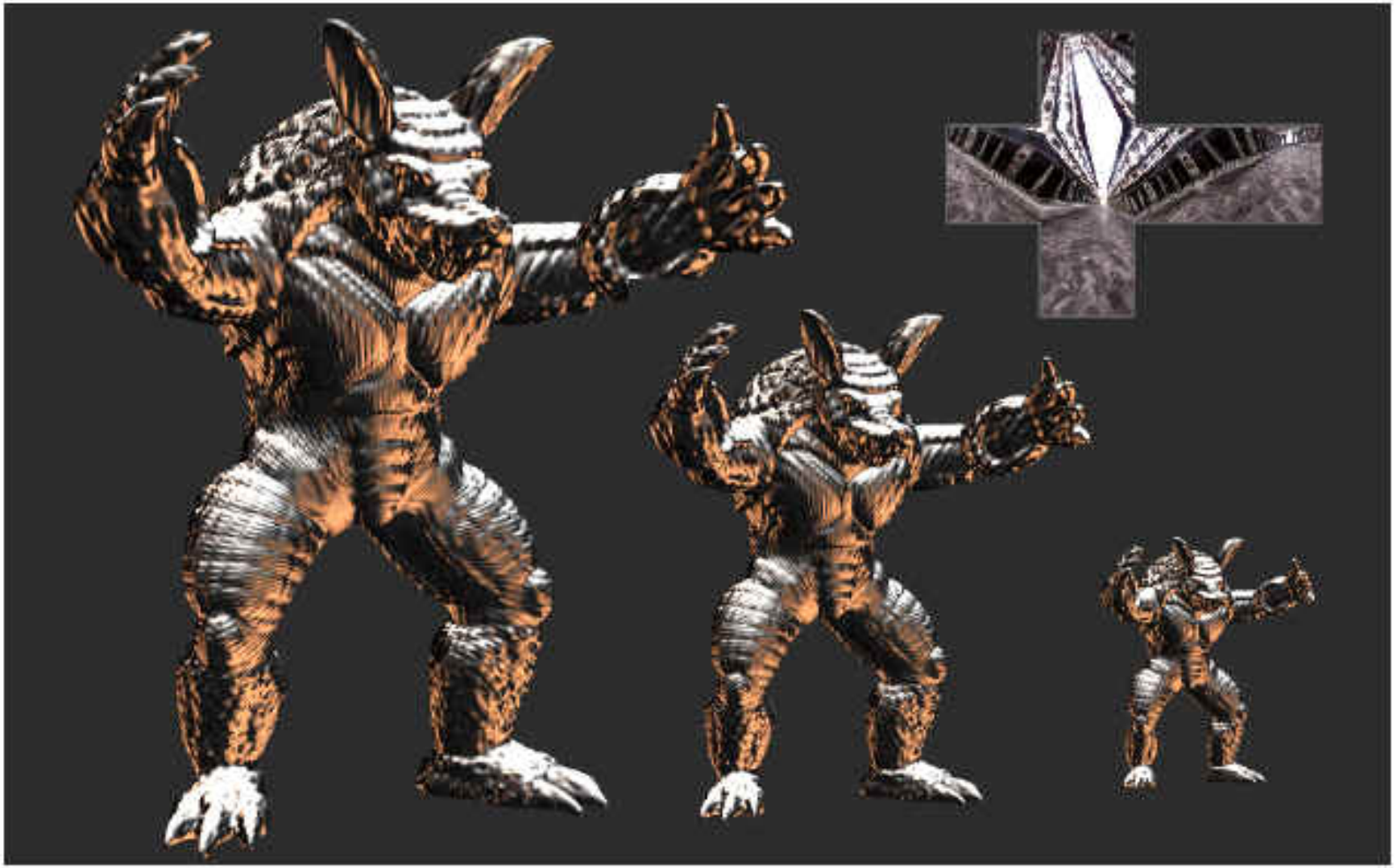


Level of Detail in Shading

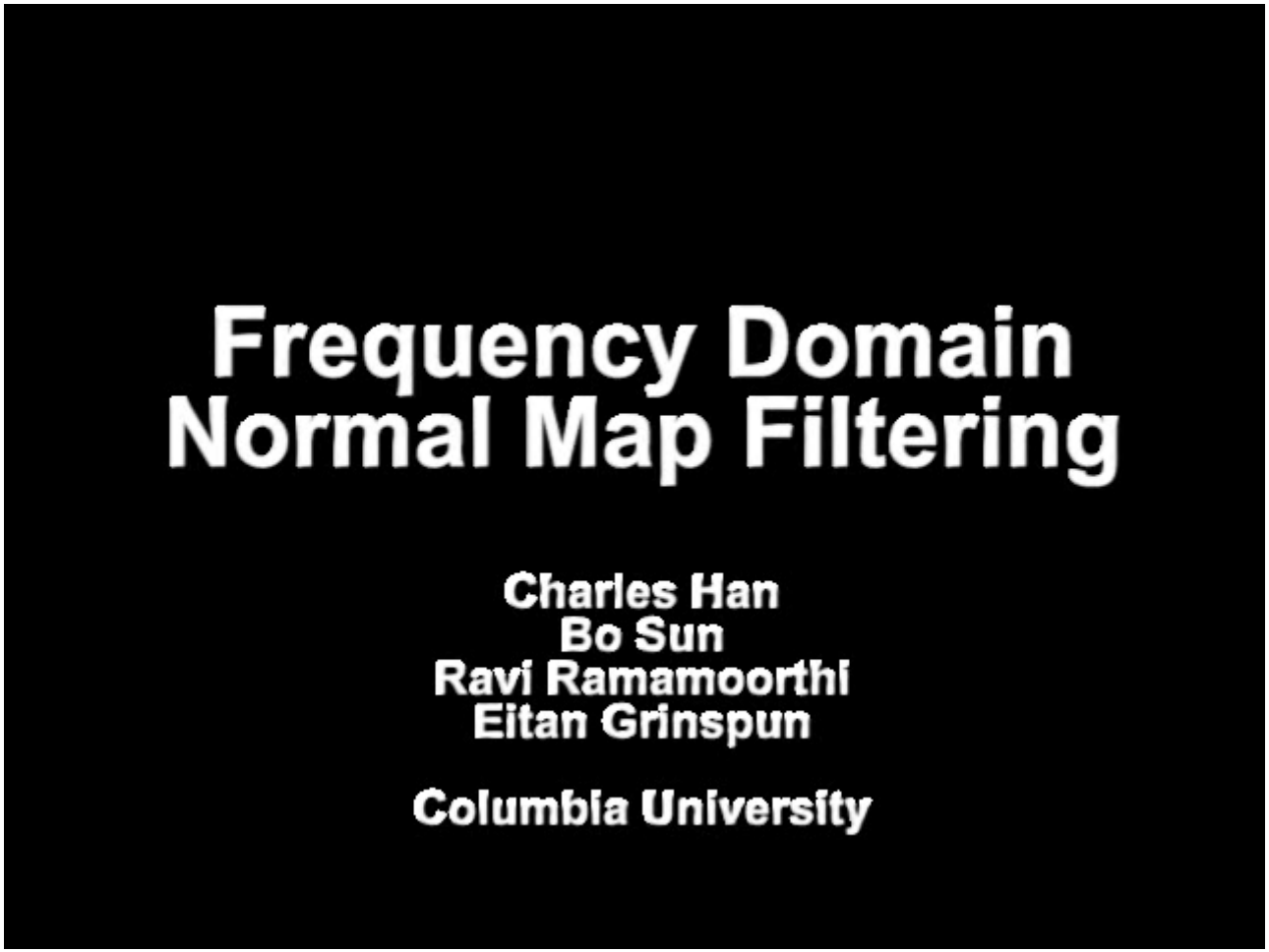
- **correct mip-mapping of bump maps**
- **multiple normal will integrate to some super-pixel**
- **consider the normal distribution function**
- **approximate NDF with a set of spherical functions**



Level of Detail in Shading

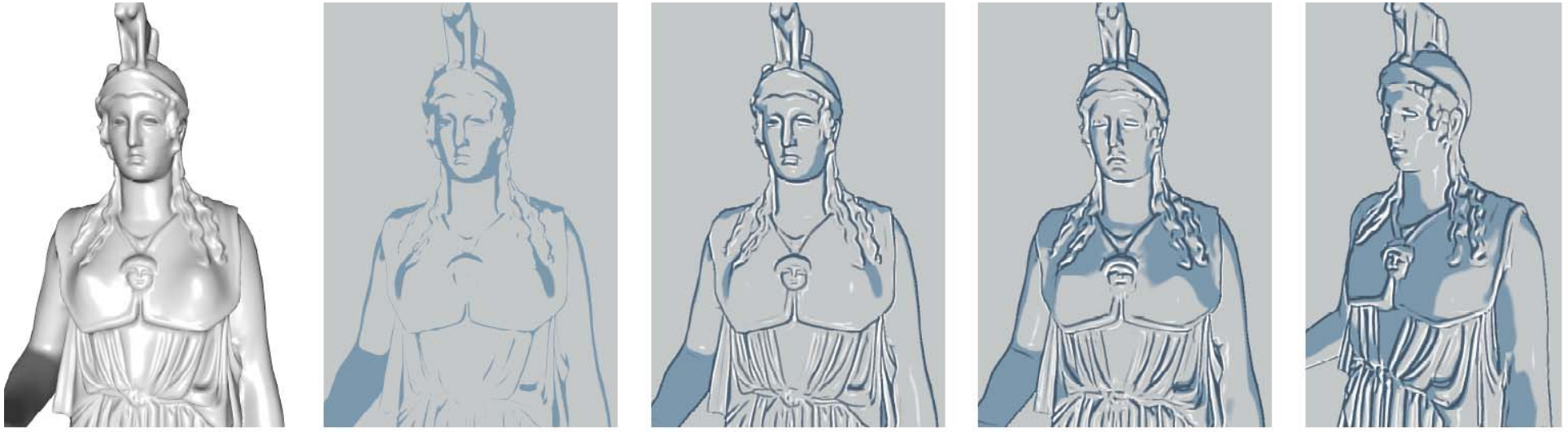


Normal Mapping



Non-Photo Realistic Rendering

- **Line Drawing Via Abstracted Shading [Markosian – SIGGRAPH 2007]**



(a) tone image (b) toon shading (c) toon shading + lines (d) new lighting (e) new lighting and view

- **NPR creates a more abstract image**
- **removal of unnecessary detail**

Ridge Detection in Tone Image

- **compute a tone image**
- **detect lines in the tone image -> abstraction**

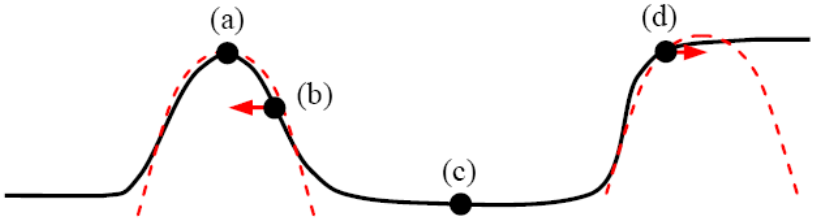
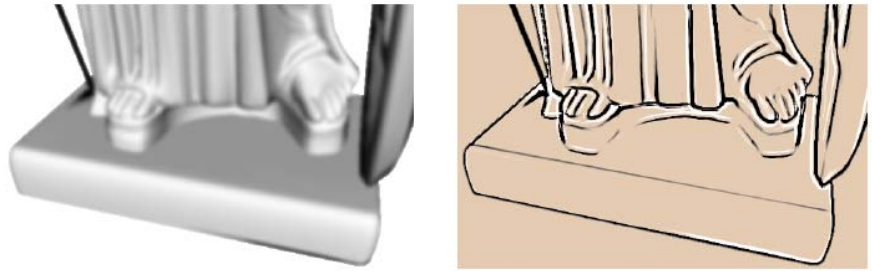
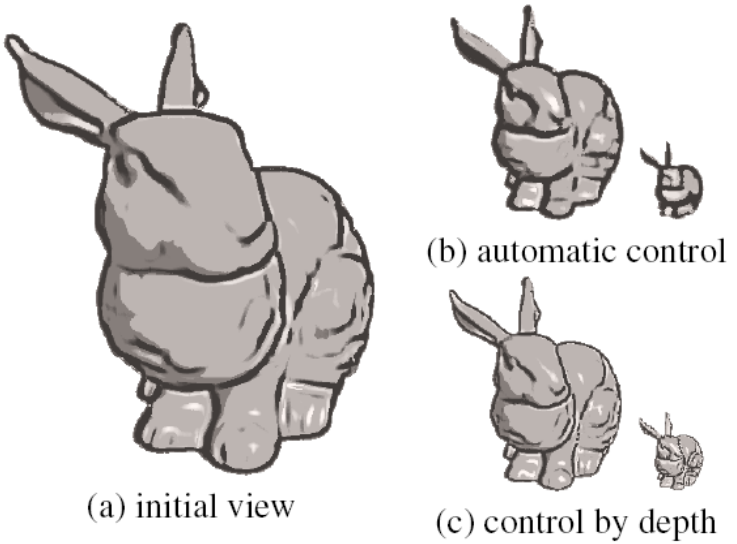


Figure 3: Ridge searching. Red dotted curves show the fitting polynomials. By refitting the polynomials after moving toward the ridge or valley, we can distinguish case (b) from case (d).



(a) tone image (b) $\beta = 0.0$

(c) $\beta = 0.3$ (d) $\beta = 1.0$



(a) initial view (b) automatic control (c) control by depth

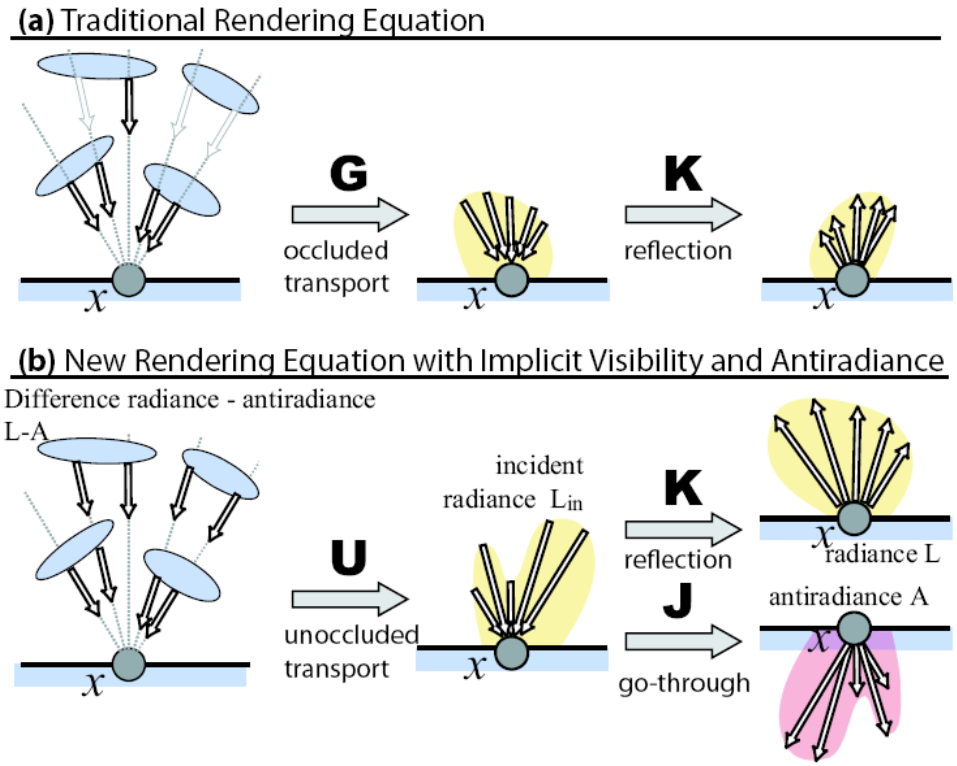
movie

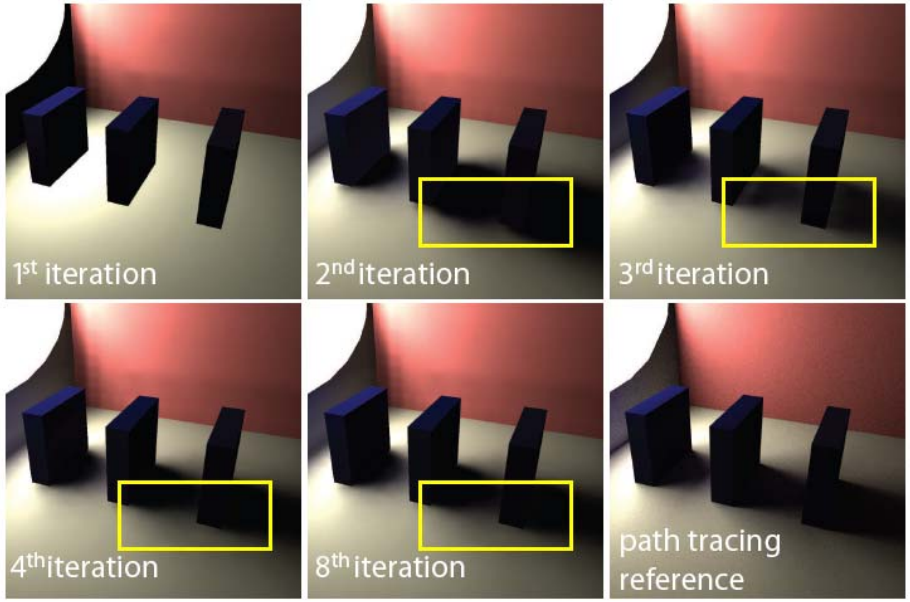
Interactive Global Illumination

- **Implicit Visibility and Antiradiance for Interactive Global Illumination [Dachsbacher et al. – SIGGRAPH 2007]**

Antiradiance

- **do not use any shadow rays**
- **simply transport negative light**
- **solve for global illumination through iteration**





Antiradiance

Image-Resizing

- **“Seam Carving for Content-Aware Image Resizing” [Avidan and Shamir, SIGGRAPH 07]**

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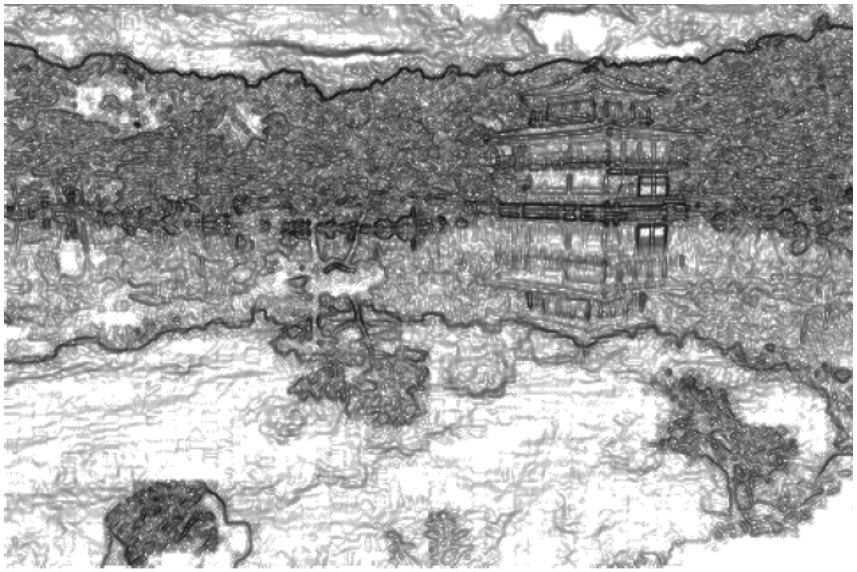
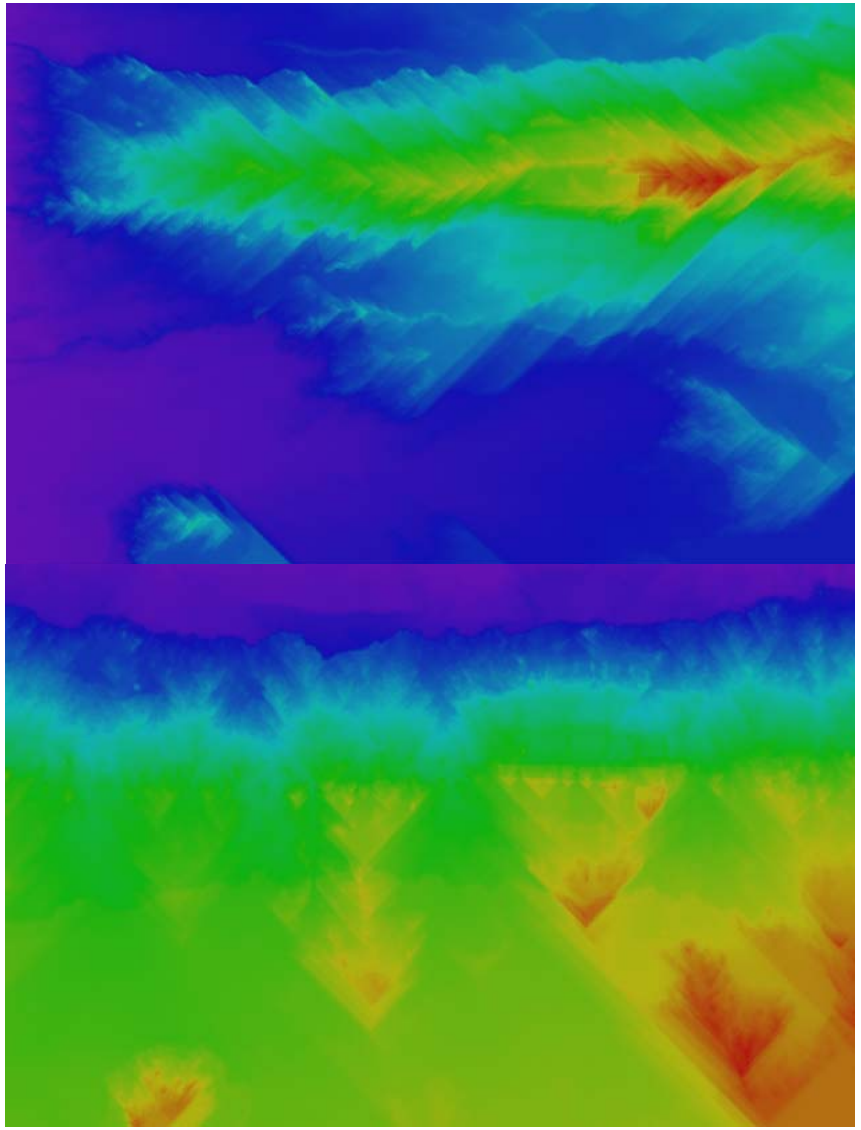
Energy Minimization



magnitude of gradient



accumulated path cost: horizontal, vertical

Algorithm

- **Find minimum path from top to bottom (left to right)**
- **Dijkstra's Algorithm O(n log n)**
- **For shrinking:**
  - iteratively remove individual seams
  - increases the energy in every step
- **For growing:**
  - iteratively insert individual seams
  - decreases the energy in every step
  - make sure not to insert at the same place over and over again, use the seams suggested for shrinking

movie

Large Images

- **Capturing and Viewing Gigapixel Images [Kopf et al. – SIGGRAPH 2007]**

movie

Physics Simulation

- **Efficient Simulation of Inextensible Cloth [Goldenthal et al. – SIGGRAPH 2007]**

- **this motion is governed by an augmented Lagrange equation**

$$L(\mathbf{x},\mathbf{v}) = \frac{1}{2}\mathbf{v}^T\mathbf{M}\mathbf{v} - V(\mathbf{x}) - \mathbf{C}(\mathbf{x})^T\boldsymbol{\lambda}$$

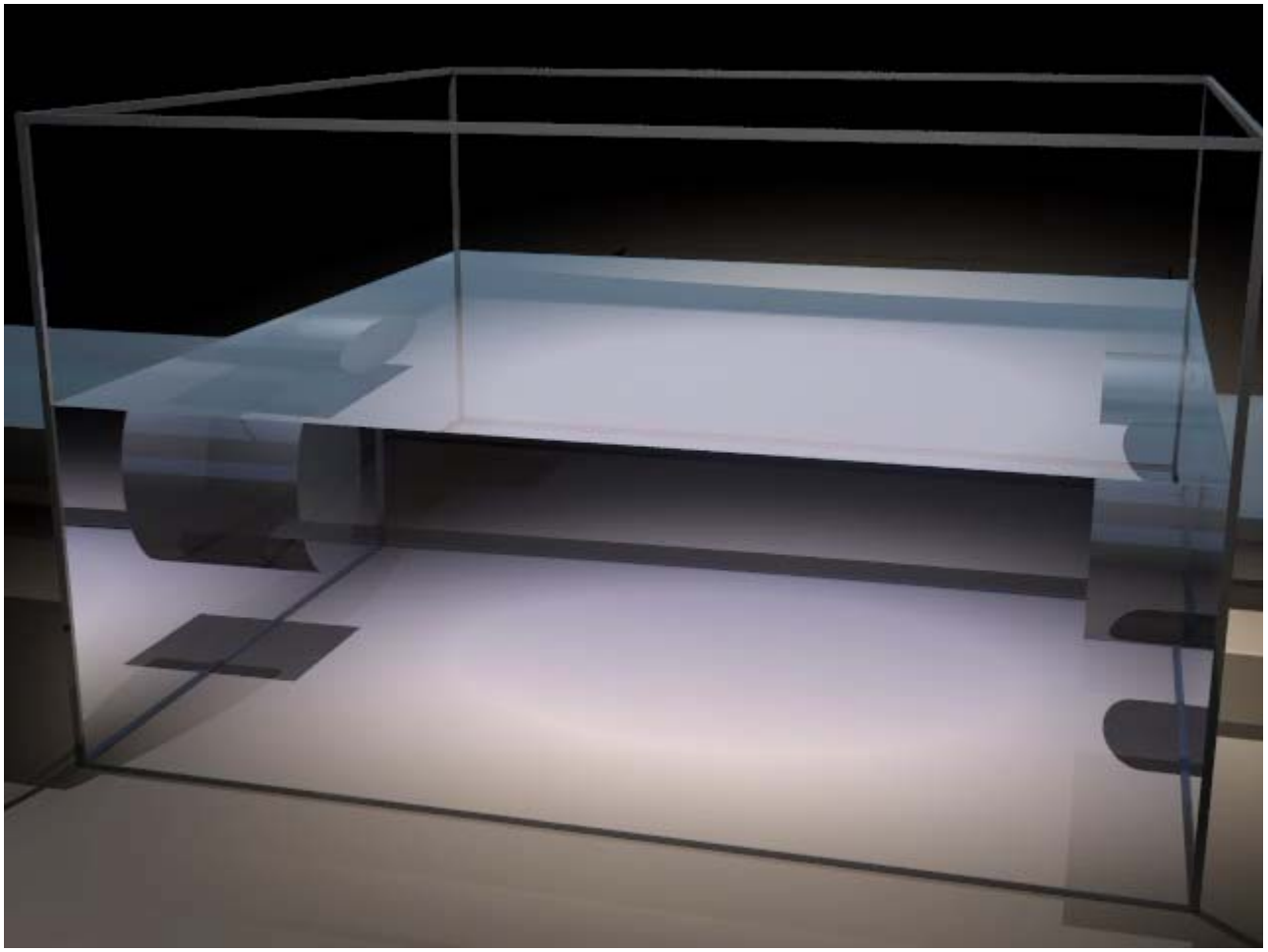
with velocity v(t), mass matrix M, bending, shear and gravity V(x), extensibility constraints C

- **efficient solution by simplification**

movie

Fluid Flow

- **Multiple Interacting Liquids [Losasso et al. – SIGGRAPH 2006]**



Fluid Flow

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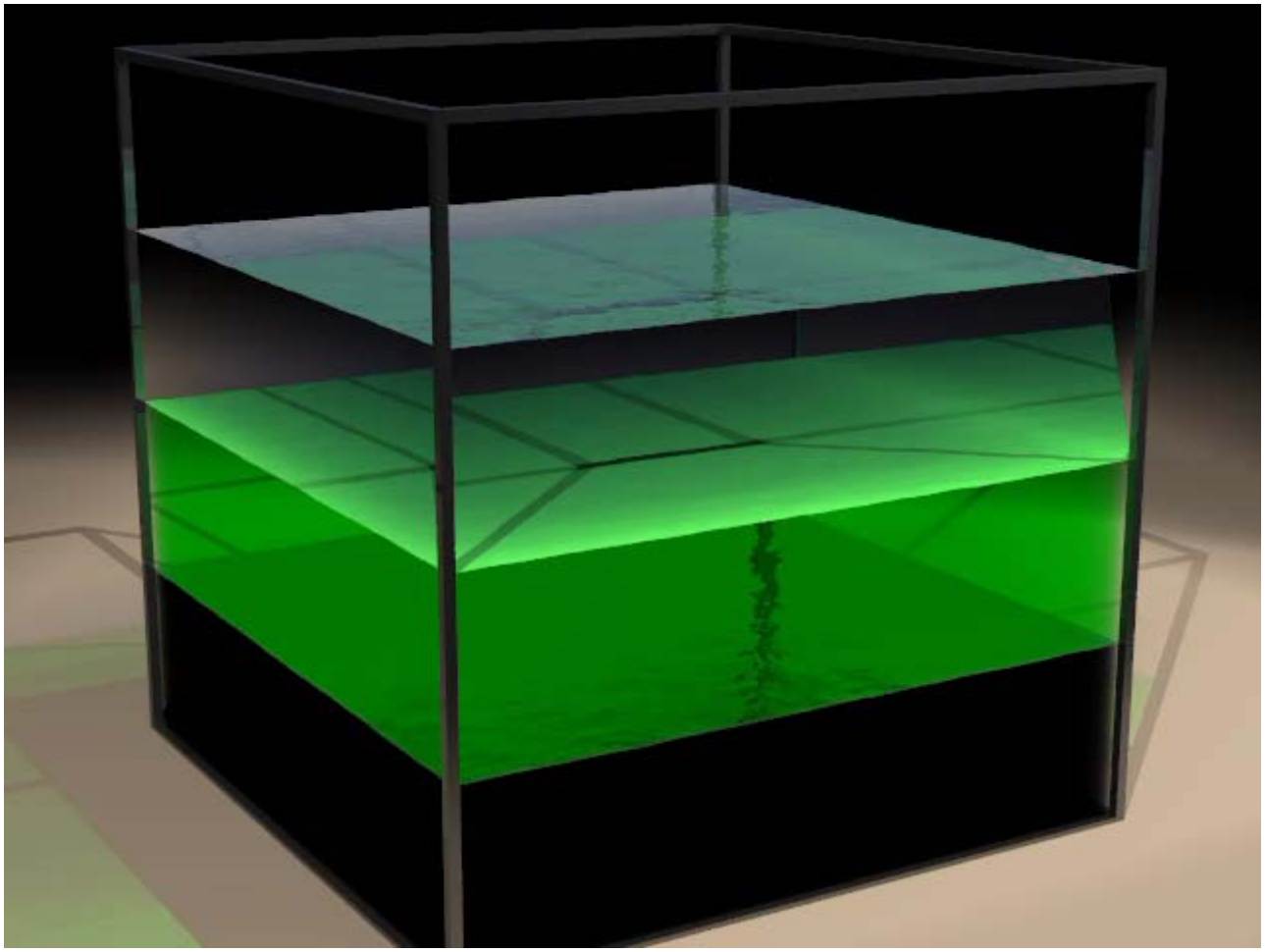


Crowd Simulation

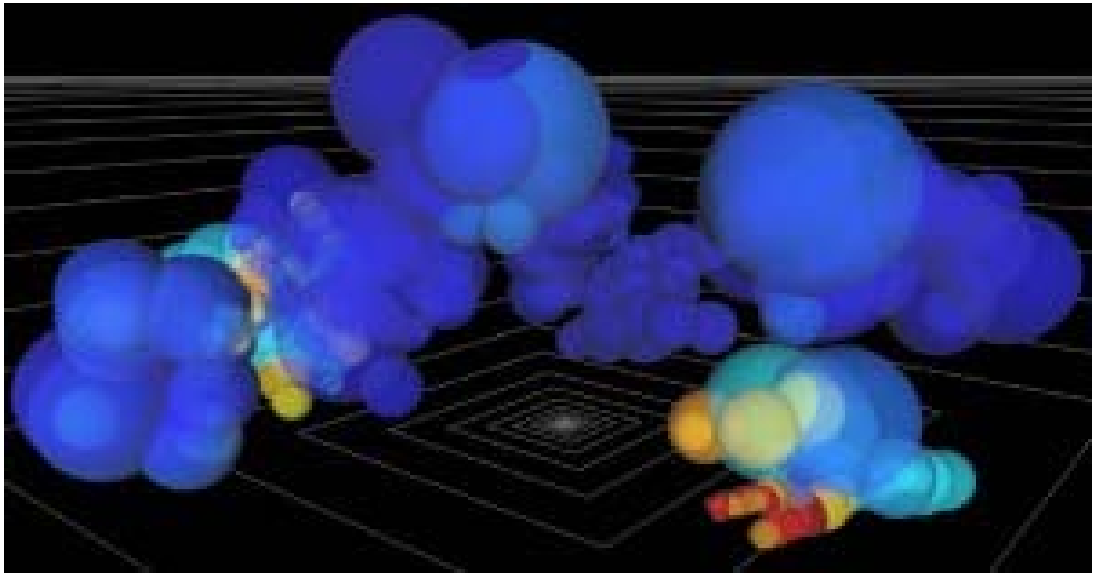
- **Continuum Crowds [Treuiller et al. – SIGGRAPH 2006]**

- **simulated using continuous dynamics**
- **implicit collision avoidance**

Crowd Simulation

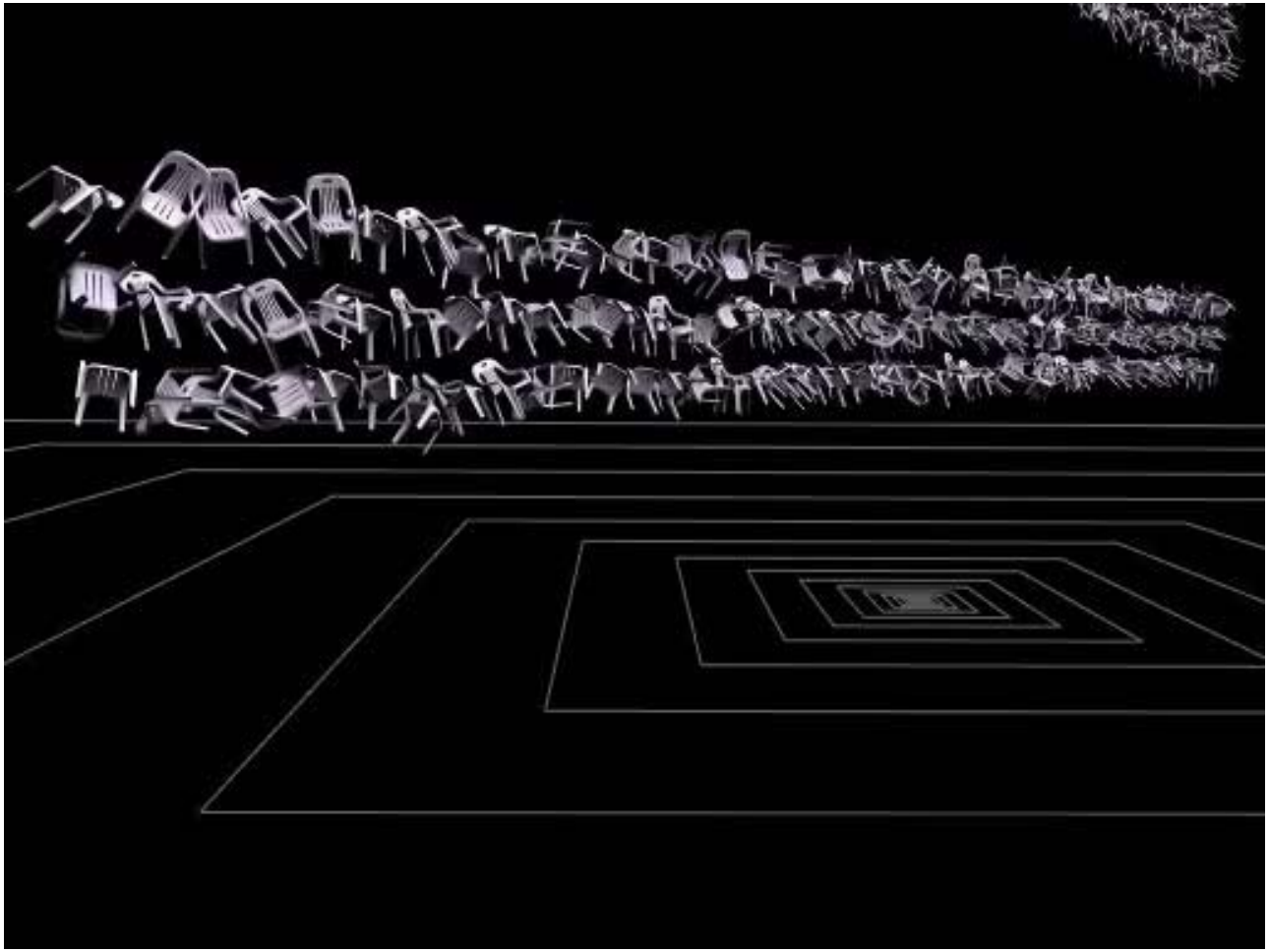
Collision Detection

- BD-Tree: Output-Sensitive Collision Detection for Reduced Deformable Models [James and Pai – SIGGRAPH 2004]



- collision handling necessary for correct physics simulation
- spatial acceleration structure to perform collision detection even of deformable objects

Collision Detection



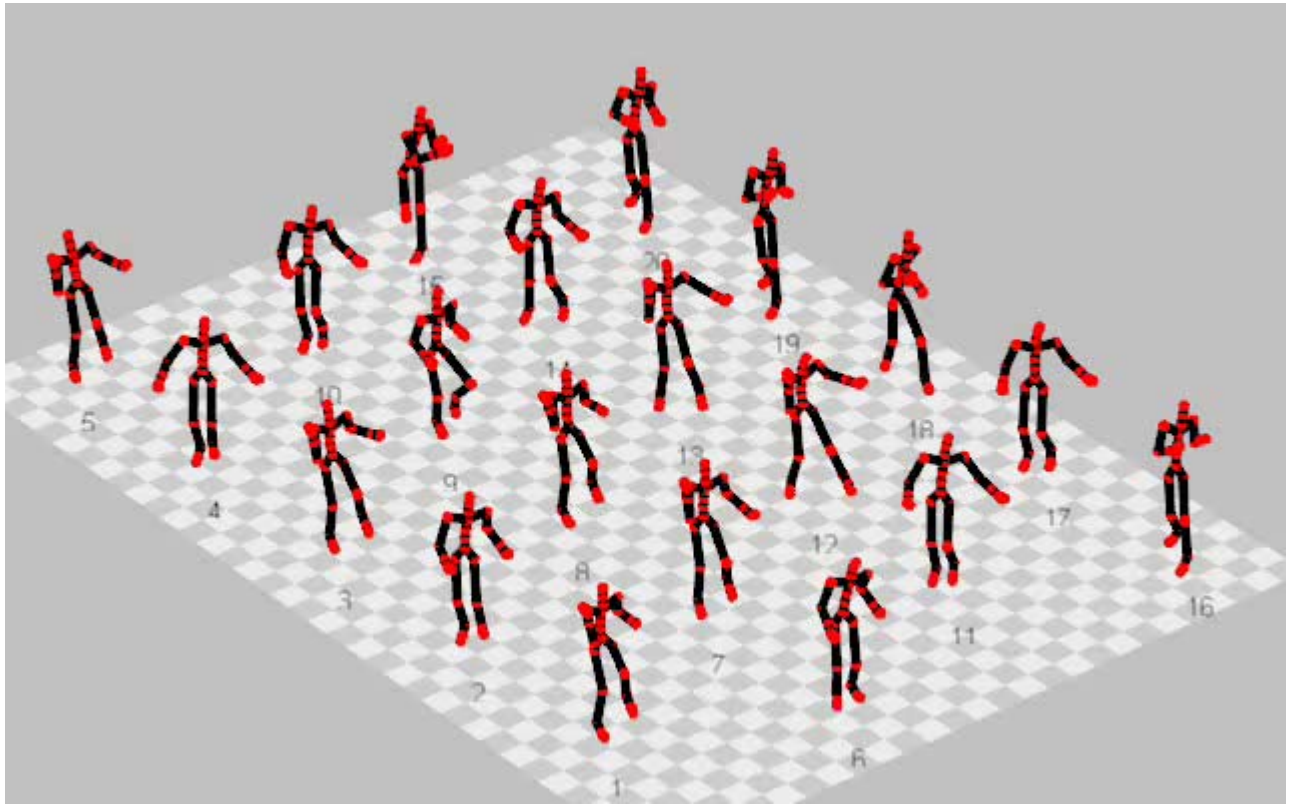
Animation of Flexible Bodies

- **FastLSM: Fast Lattice Shape Matching for Robust Real-Time Deformation [Rivers&James – SIGGRAPH 2007]**

Current Topics at MPI Department 4 Computer Graphics

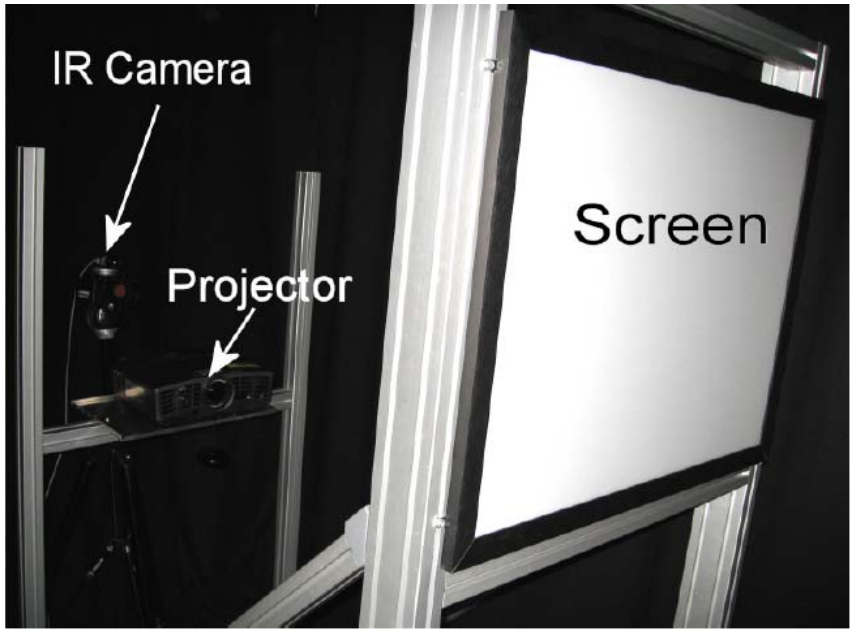
Motion Retrieval

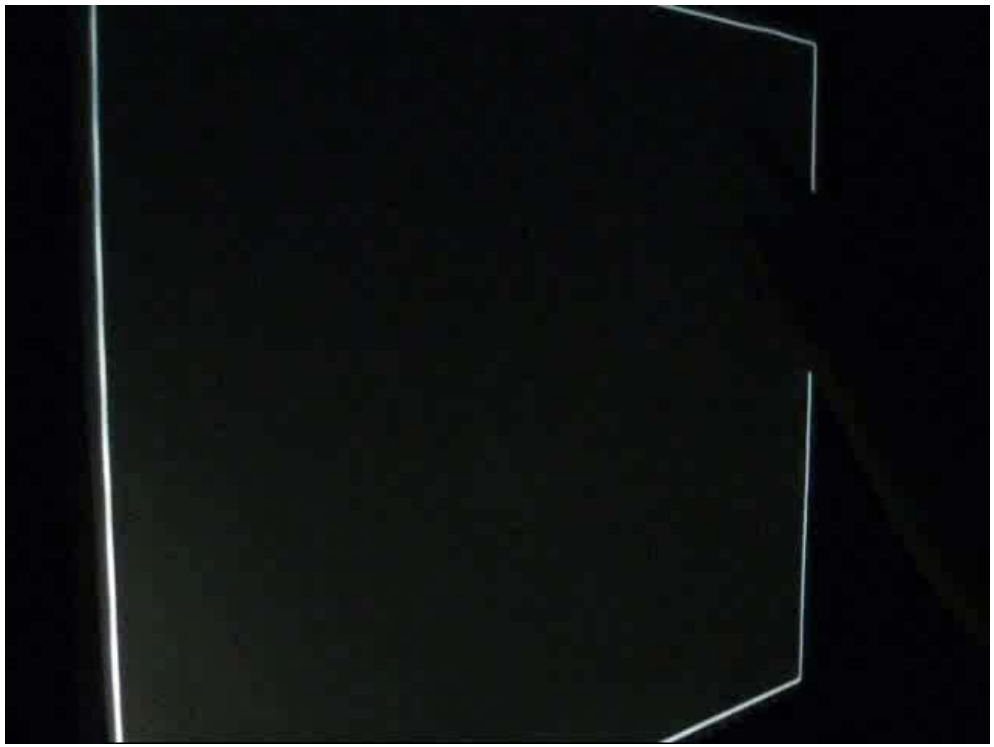
- **given a small motion sequence determine segments that perform a similar motion**

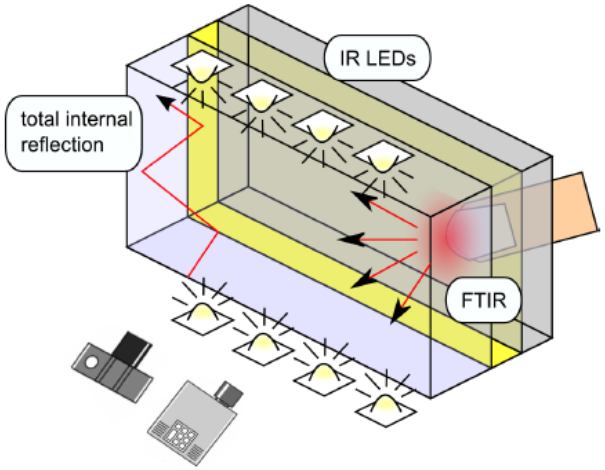


Multi-Touch-Display

- **3D modeling application**



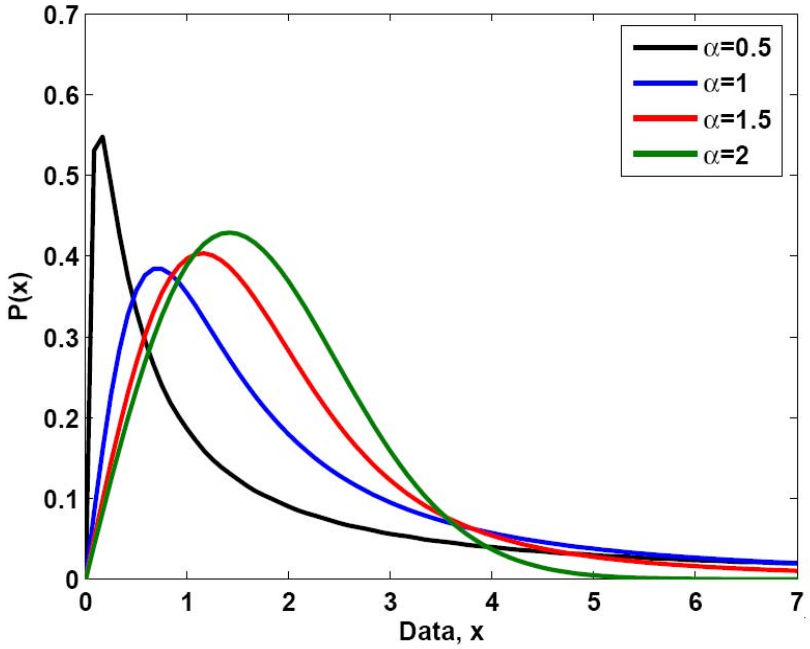




tracking: 100Hz
using Cuda

Global Image Statistics

- **Image gradients (color difference between neighboring pixels)**
- **Heavy-tail distribution function on a global scale**

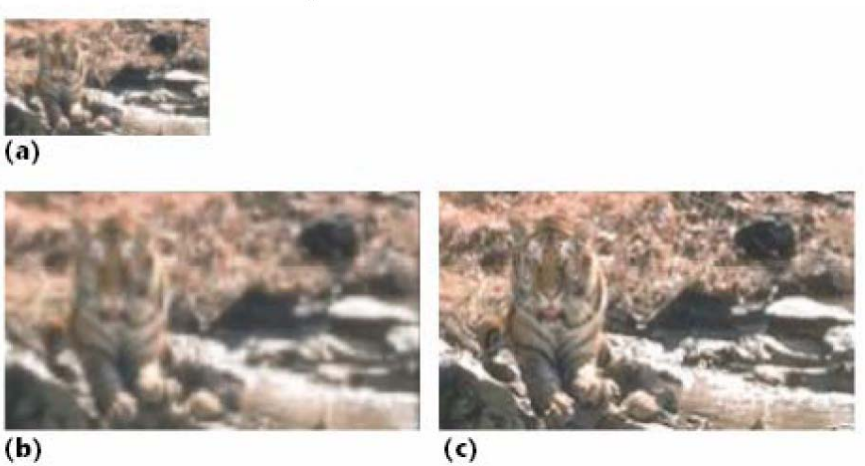


Local Image Statistics

- **Global statistics do not allow subtle local changes within the images**
- **We have developed a novel objective function which should correspond to naturally looking images**
- **It is defined on a small pixel neighborhood, allowing for easy pixel reconstruction.**
- **Applied to image demosaicing.**

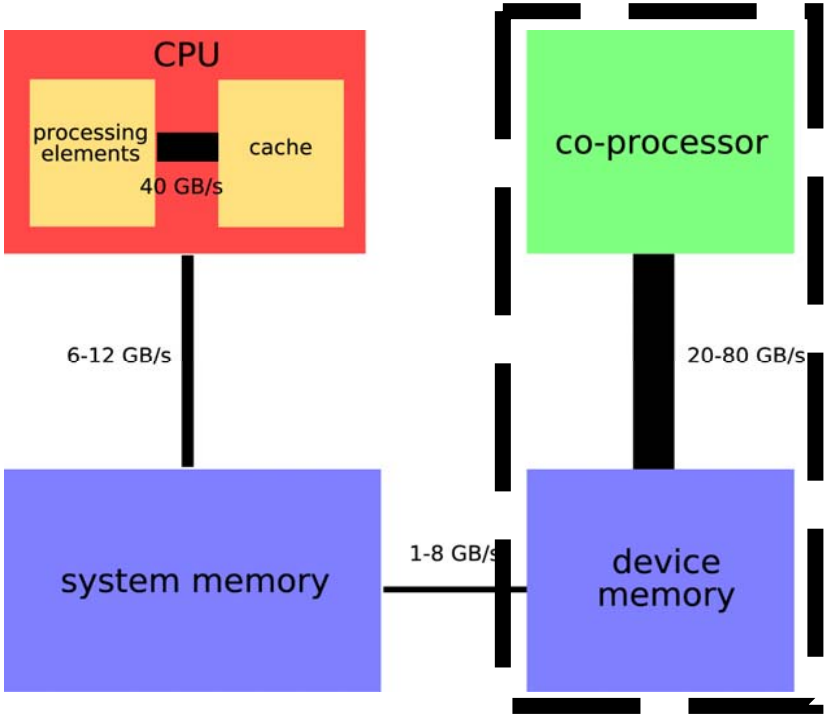
Proposed work

- **Acquiring a large high quality full RGB image datasets (internet, our cameras).**
- **Further testing the objective function – possible adjustments.**
- **Code optimization (implementing CUDA)**
- **Applications to image denoising, upsampling, ...**

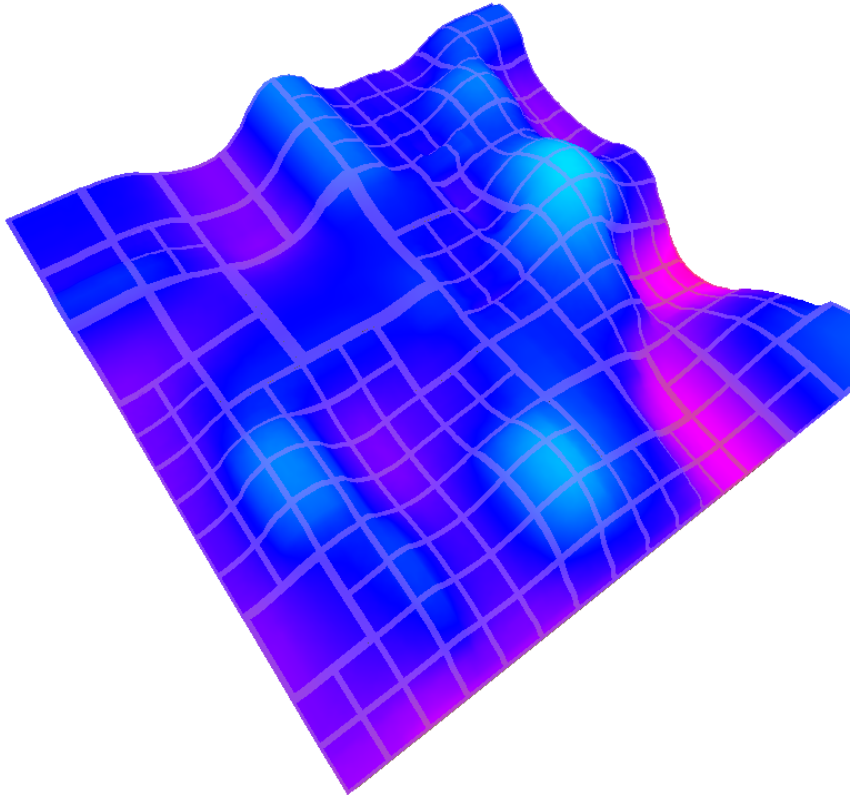


Scientific Computing with GPUs

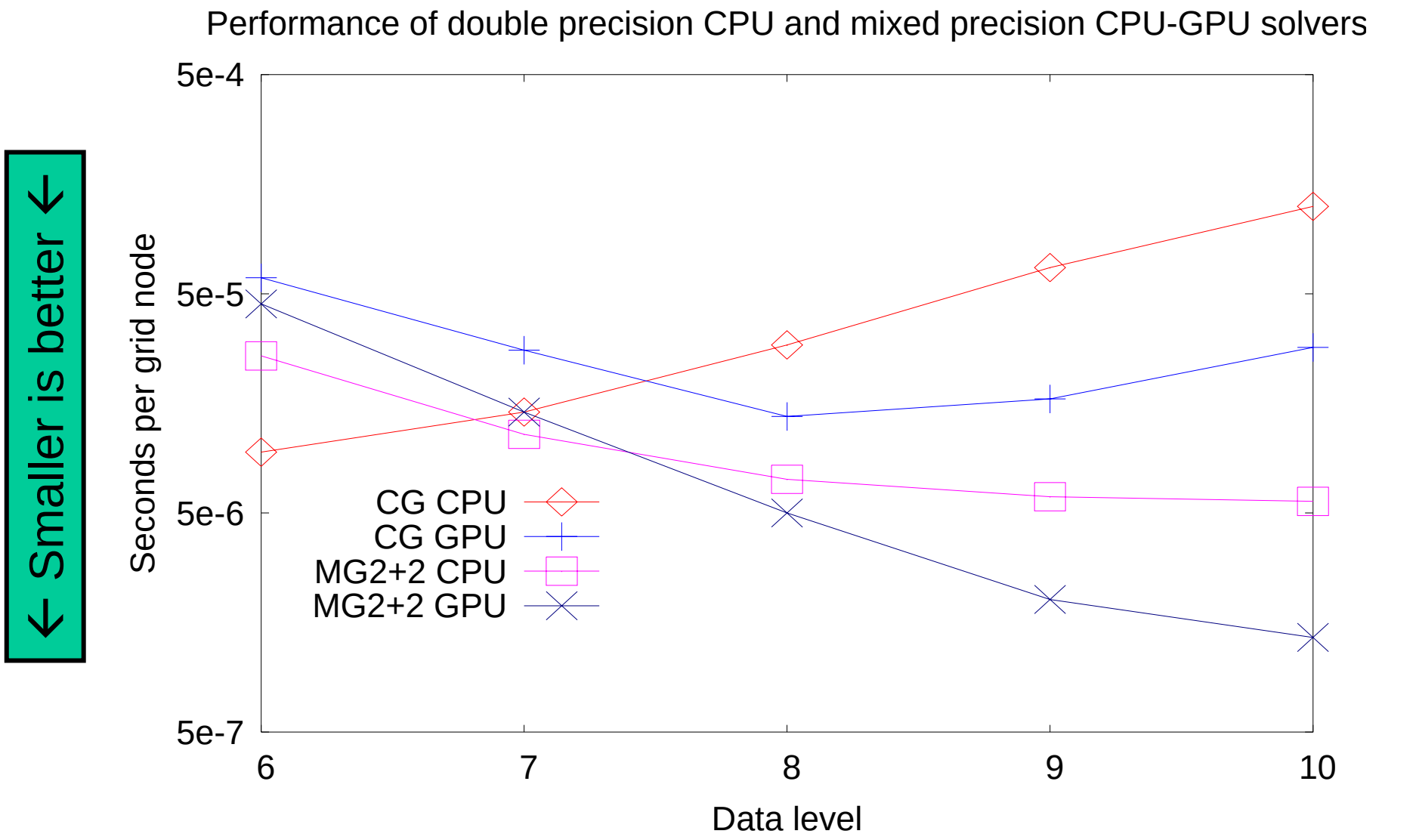
Accelerator Node with PCI (Express) Connection



Heat distribution on a chip under load

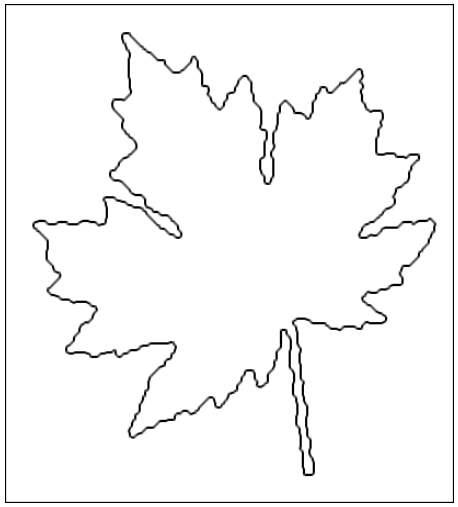


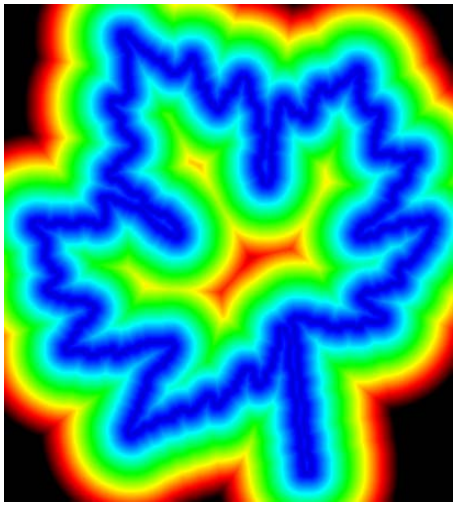
GPU Results: Conjugate Gradient (CG) and Multigrid (MG)



Distance Transforms and Skeletons

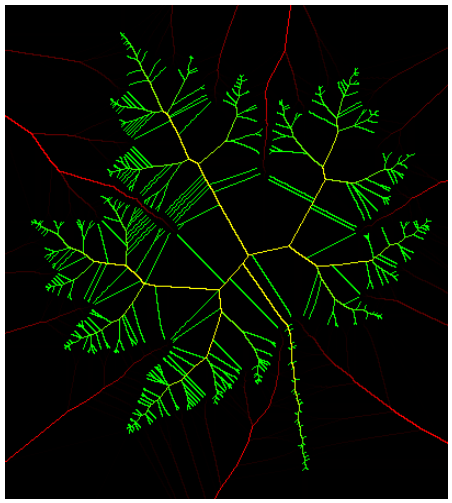
original boundary

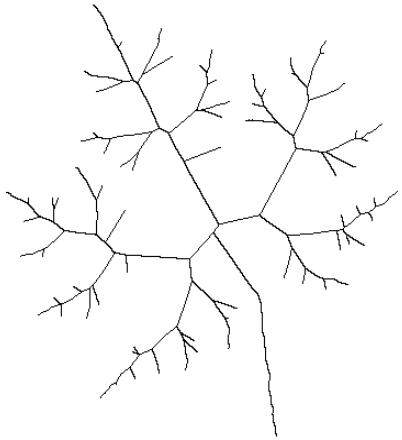




distance transform

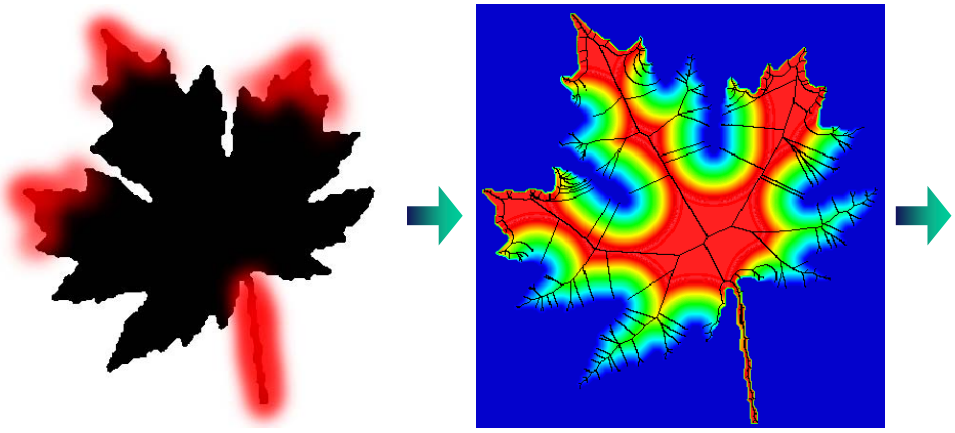
fine skeleton



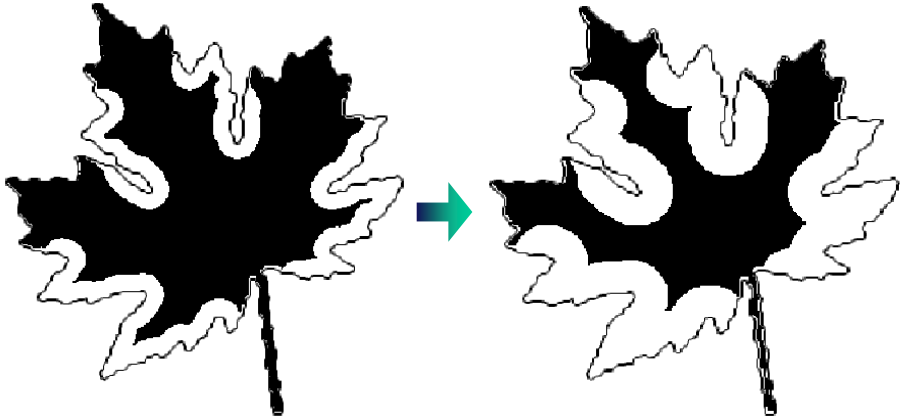


trimmed skeleton

Feature-Preserving Simplification

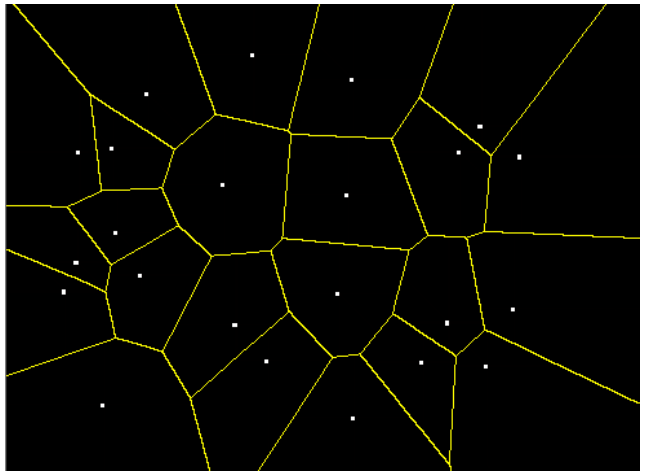


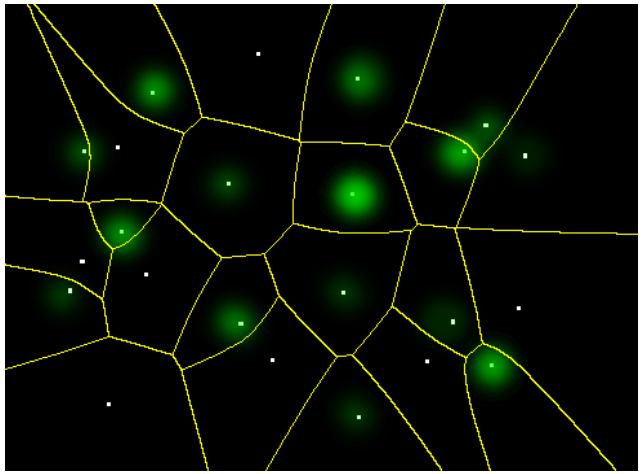
paint features compute DT

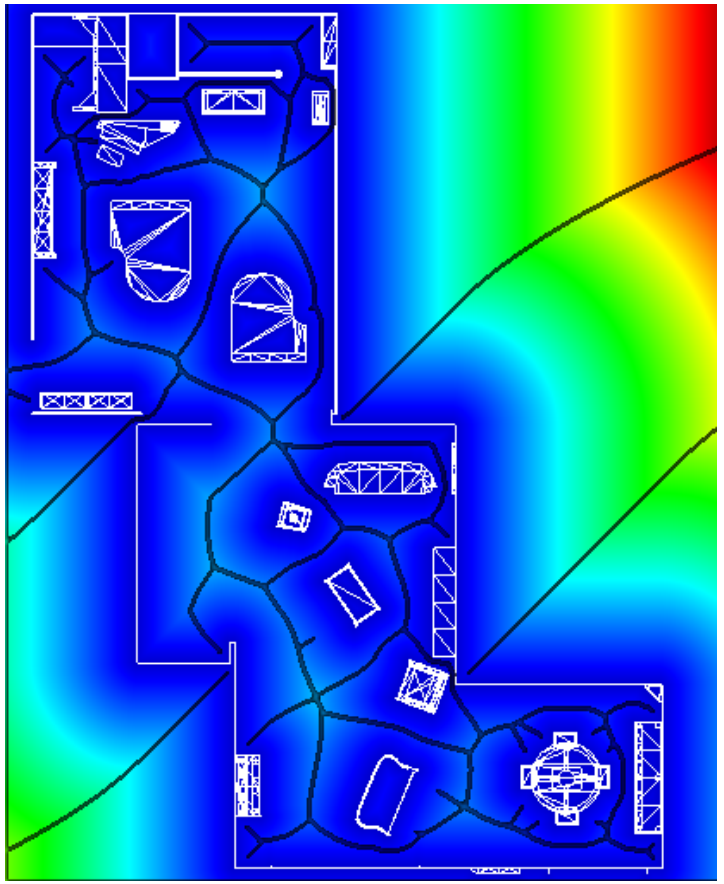


simplify simplify

Distance Transforms and Voronoi Diagrams







⬅ Generalized weighted Voronoi diagram

Motion Estimation – Feature Extraction

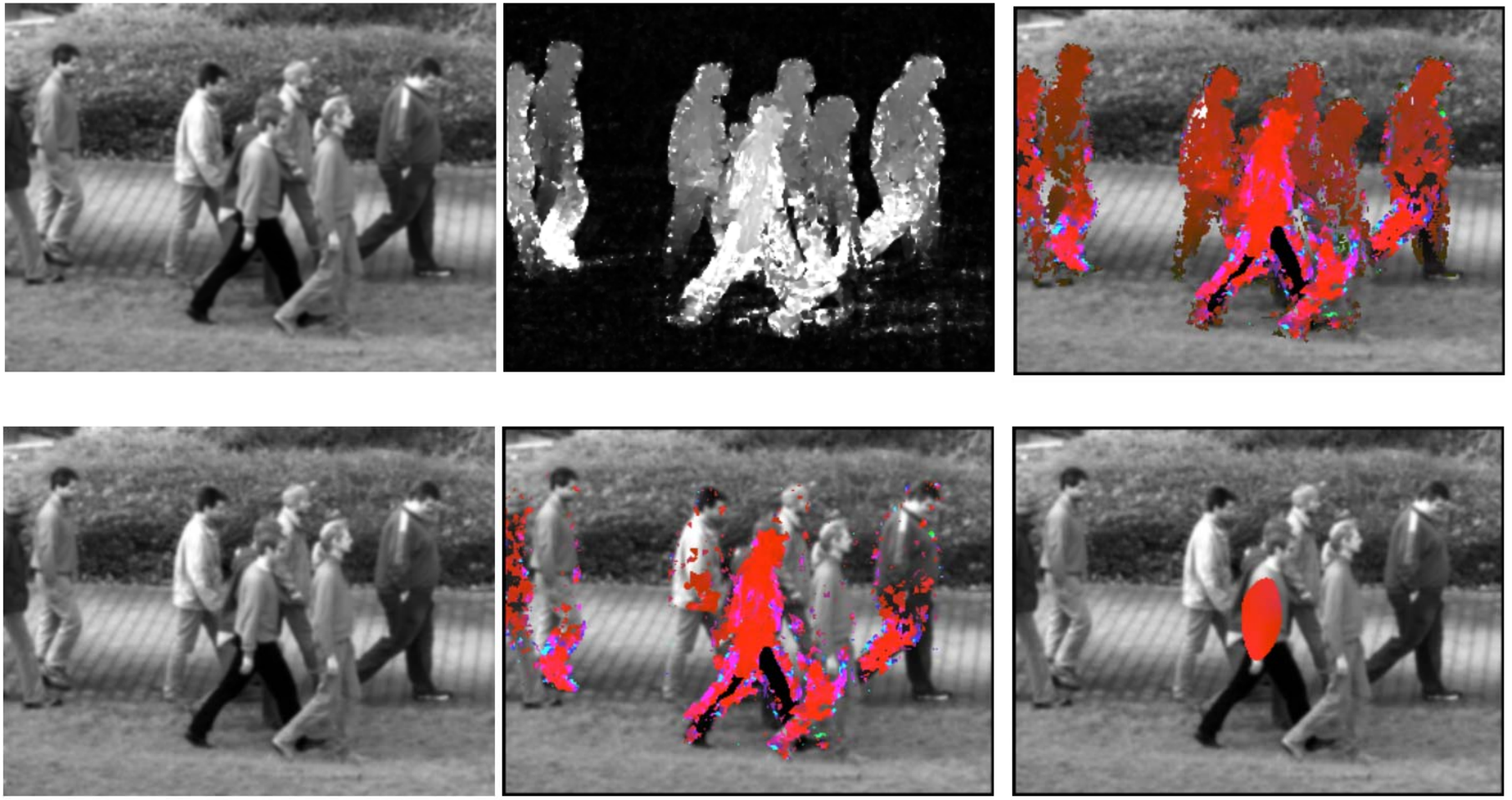
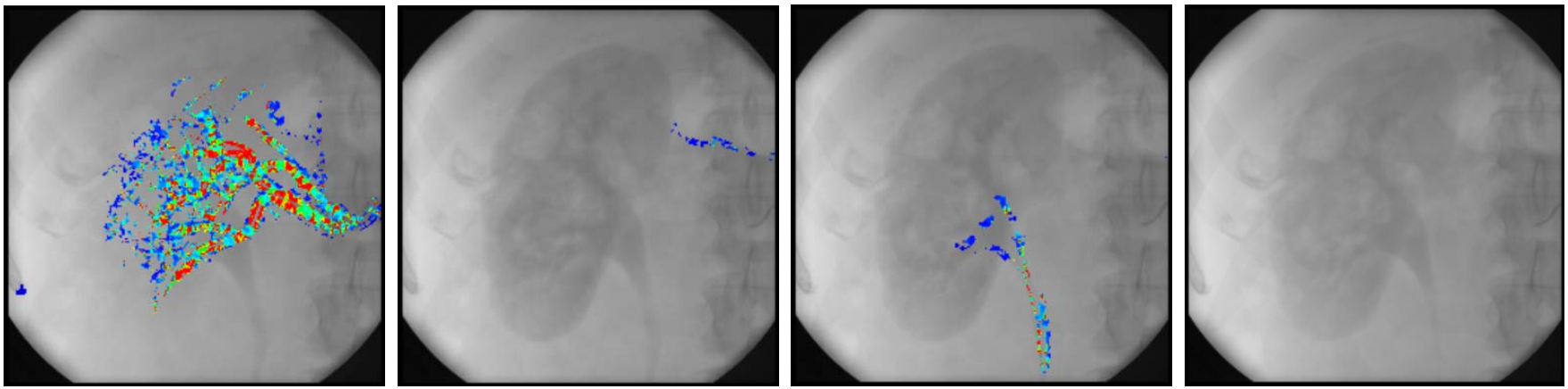


Fig1a.mov Fig1d.mov Fig1e.mov Fig1g.mov

[Strzodka and Garbe, Visualization 2004]

Motion Estimation – Blood Visualization



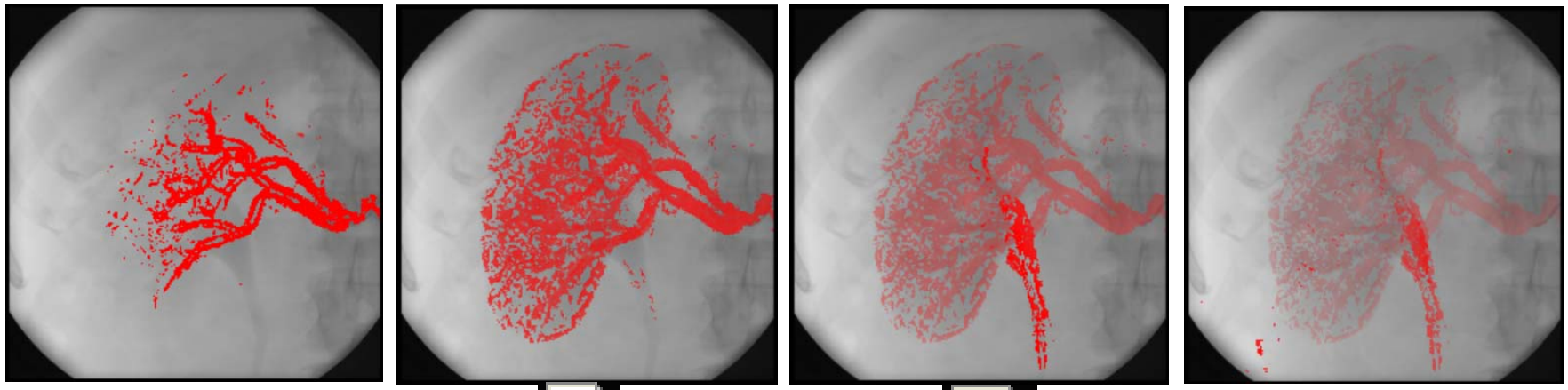


Fig8ppre.mov

Fig8abc.mov

3D-Reconstruction from Video

Differential Photon Mapping

- **Special version of photon mapping for augmenting photographs**
  - Simulates the difference in illumination introduced by virtual objects
- **Bachelor Thesis**
  - Include Final Gathering in the existing photon mapper
  - Thorsten Grosch
  - (tgrosch@mpi-inf.mpg.de)