3D rendering

Overview

- Introduction
- 3D Projection
  - Raytracing
  - Modes for 3D rendering
- Volume Rendering
  - Maximum intensity projection
  - Direct Volume Rendering
- Isosurface Rendering
  - Wireframing
- Sofware
  - Amira
  - Imaris
  - ImageJ

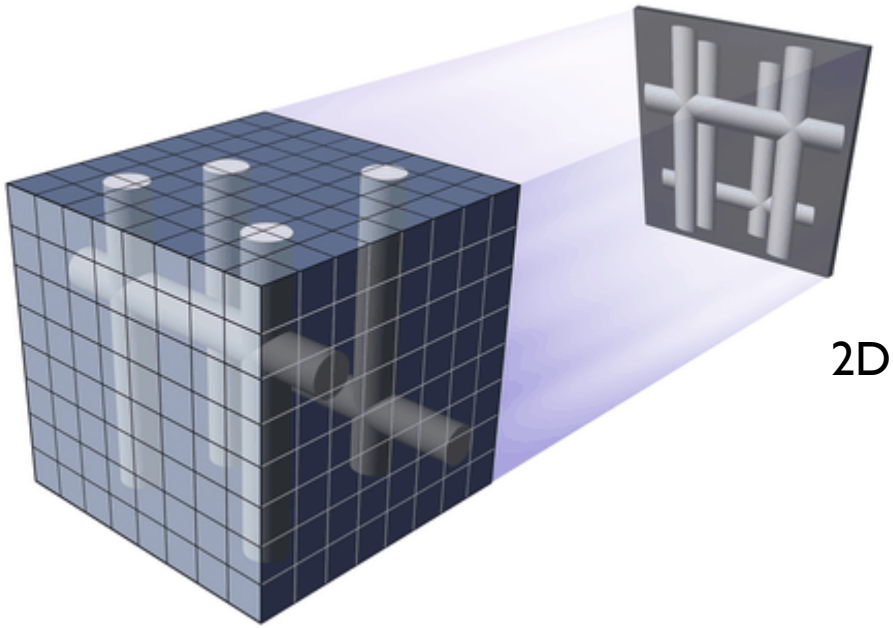
Introduction

Rendering:

- Creating a 2D-image from a 3D-model in a computer program via projection.
- 3 main possibilities:
  - Direct volume rendering
  - Maximum Intensity projection
  - Threshold based rendering (Isosurface rendering)

3D Projection

- Any method of mapping three-dimensional points to a two-dimensional plane (screen).
- Accomplished by ray tracing or other algorithms
- Each pixel of the screen is virtually represented in the frame buffer

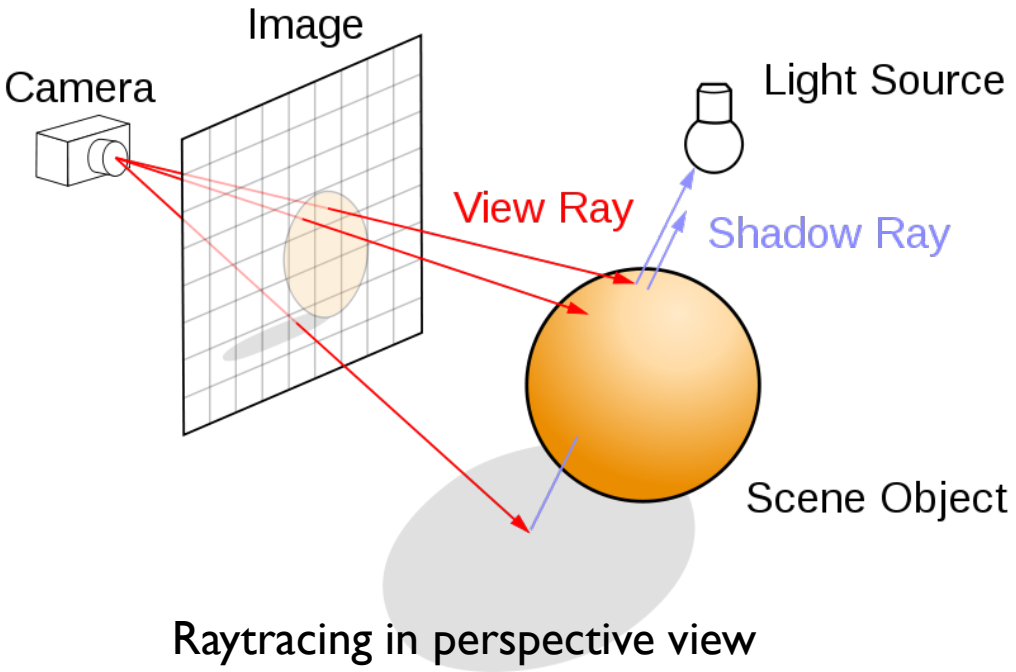


2D - Image

3D - Model

3D Projection

- Raytracing
  - generating an image by tracing the path of light through pixels in an image plane
  - Decision of visibility and appearance of object points by algorithms
  - Orthogonal and perspective view
  - Image on Screen can be saved as a snapshot, a series of images as a movie

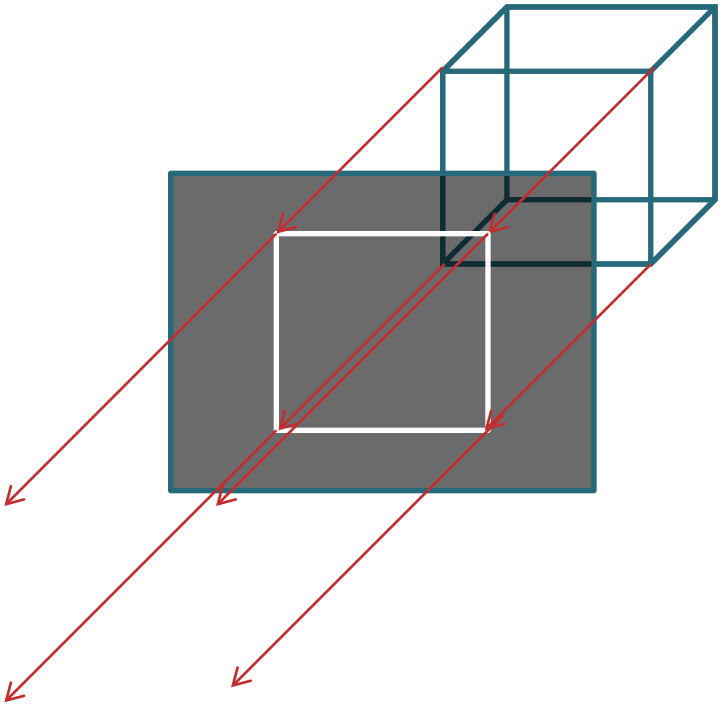


Raytracing in perspective view

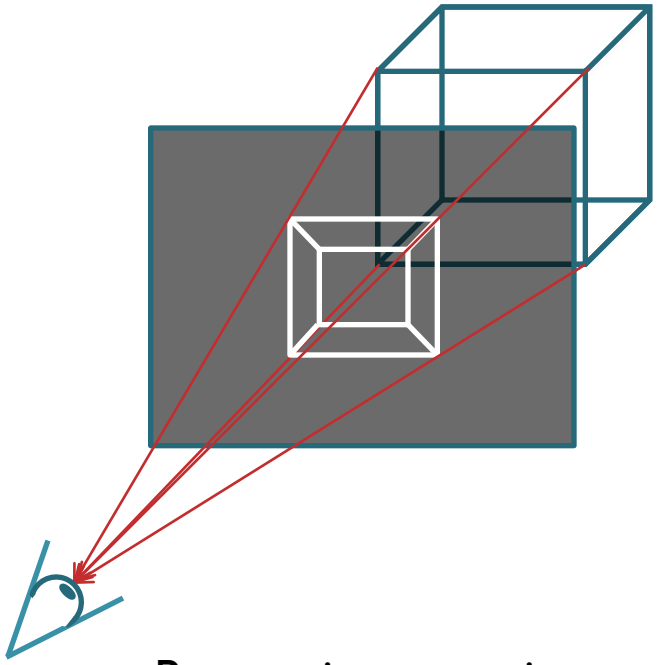
3D Projection

Orthogonal vs. perspective raytracing

- Perspective raytracing looks more familiar to the human eye.
- Orthogonal raytracing preserves distances in xy



Orthogonal raytracing



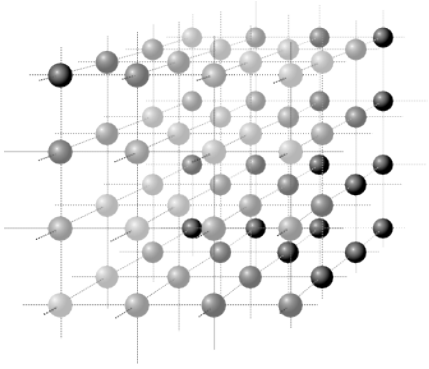
Perspective raytracing

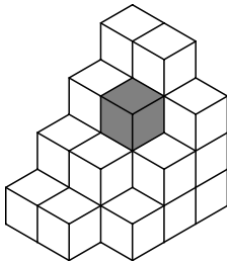
3D Visualisation Methods

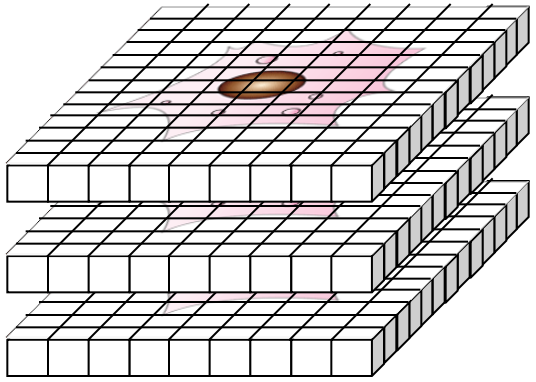
- 3 Main Possibilities:
  - Maximum Intensity Projection (MIP)
  - Direct Volume Rendering
  - Surface Rendering

The Voxel

- Scientific 3D imaging is based on voxels.
- Voxels are the smallest information unit of an image in 3D
- A series of 2D-images can be arranged into a stack.
- X,Y and Z extend of the Voxels have to be kown for correct displaying and later measurements.

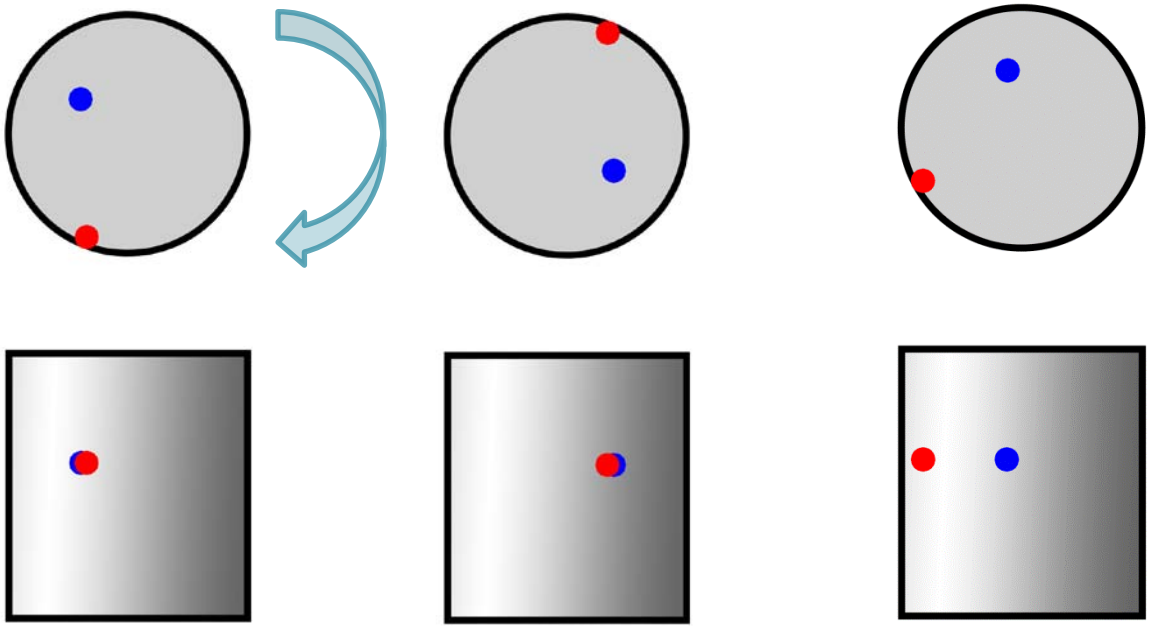






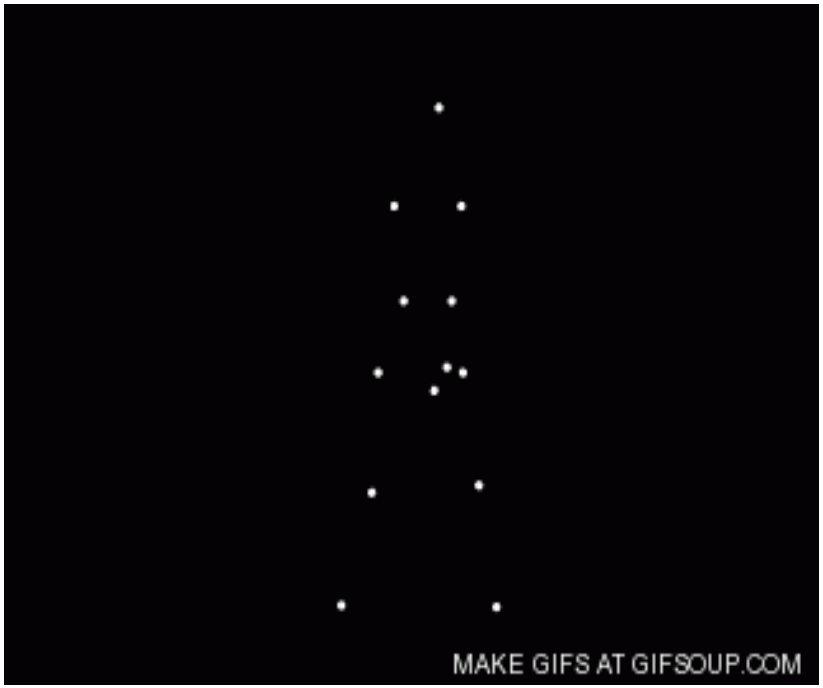
MIP - Maximum Intensity Projection

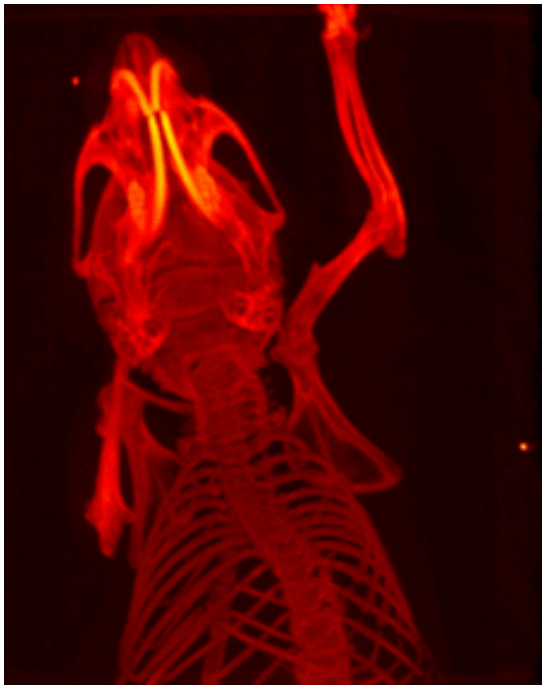
- Display of the brightest Point along the optical axis
- Optical axis through stack can be changed – interpolation of pixels
  - Bright Spot
  - Dark Spot



MIP - Maximum Intensity Projection

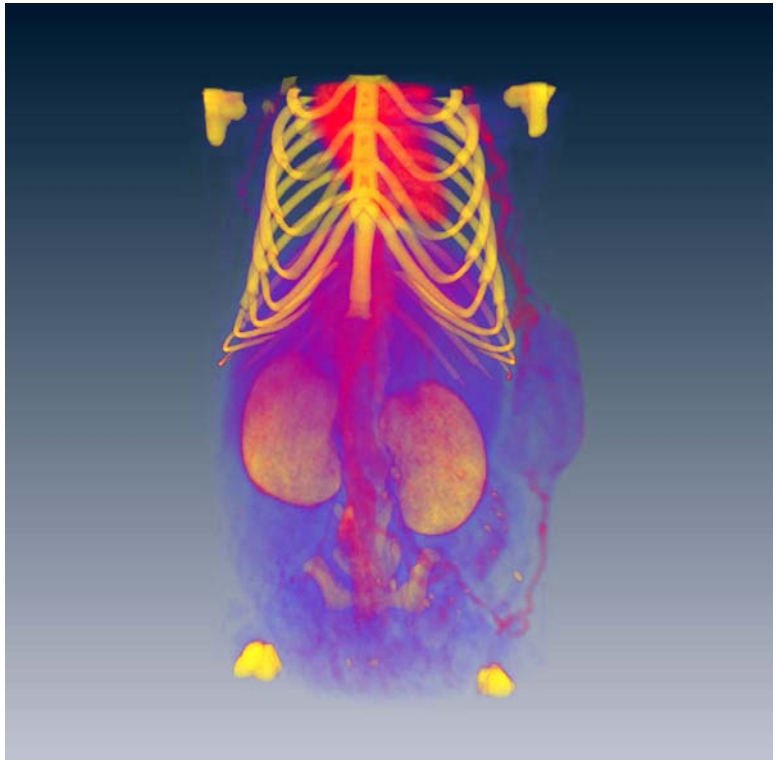
- Movement gives the impression of depth
- Position of pixel in z cannot be determined



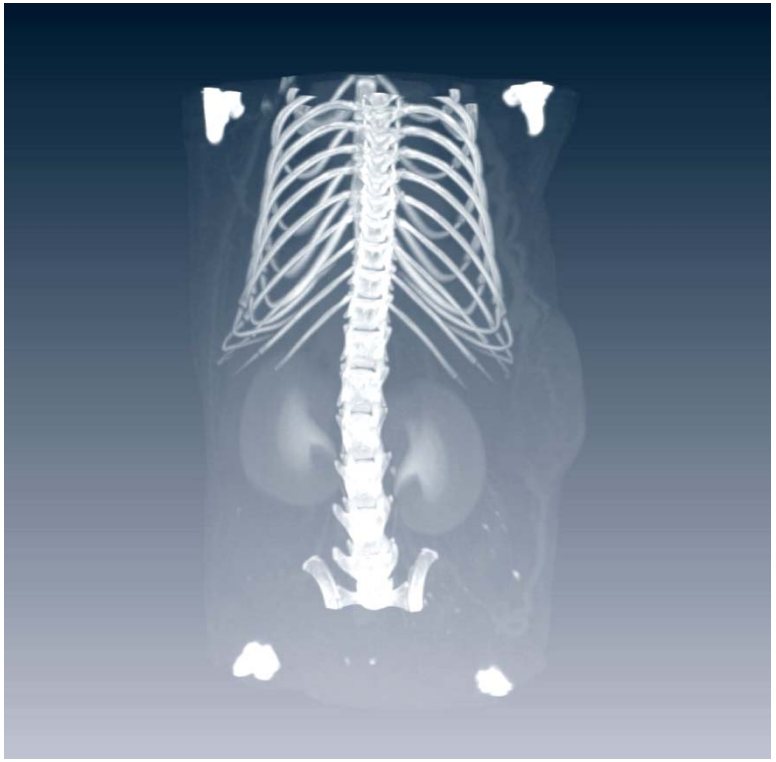


Direct Volume Rendering

- Color, and transparency and shading are based on pixel intensity
- Position of pixel is also reflected in the output – enhanced 3D impression
- Different algorithms used in different Softwares



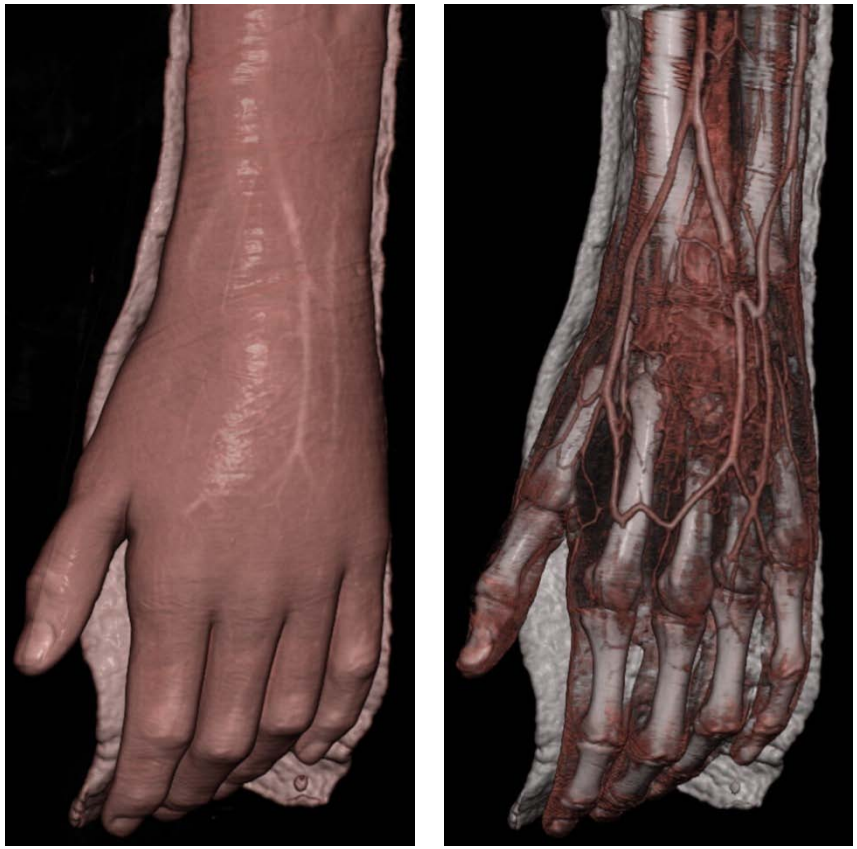
VRT – rendering in AMIRA



MIP – rendering in AMIRA

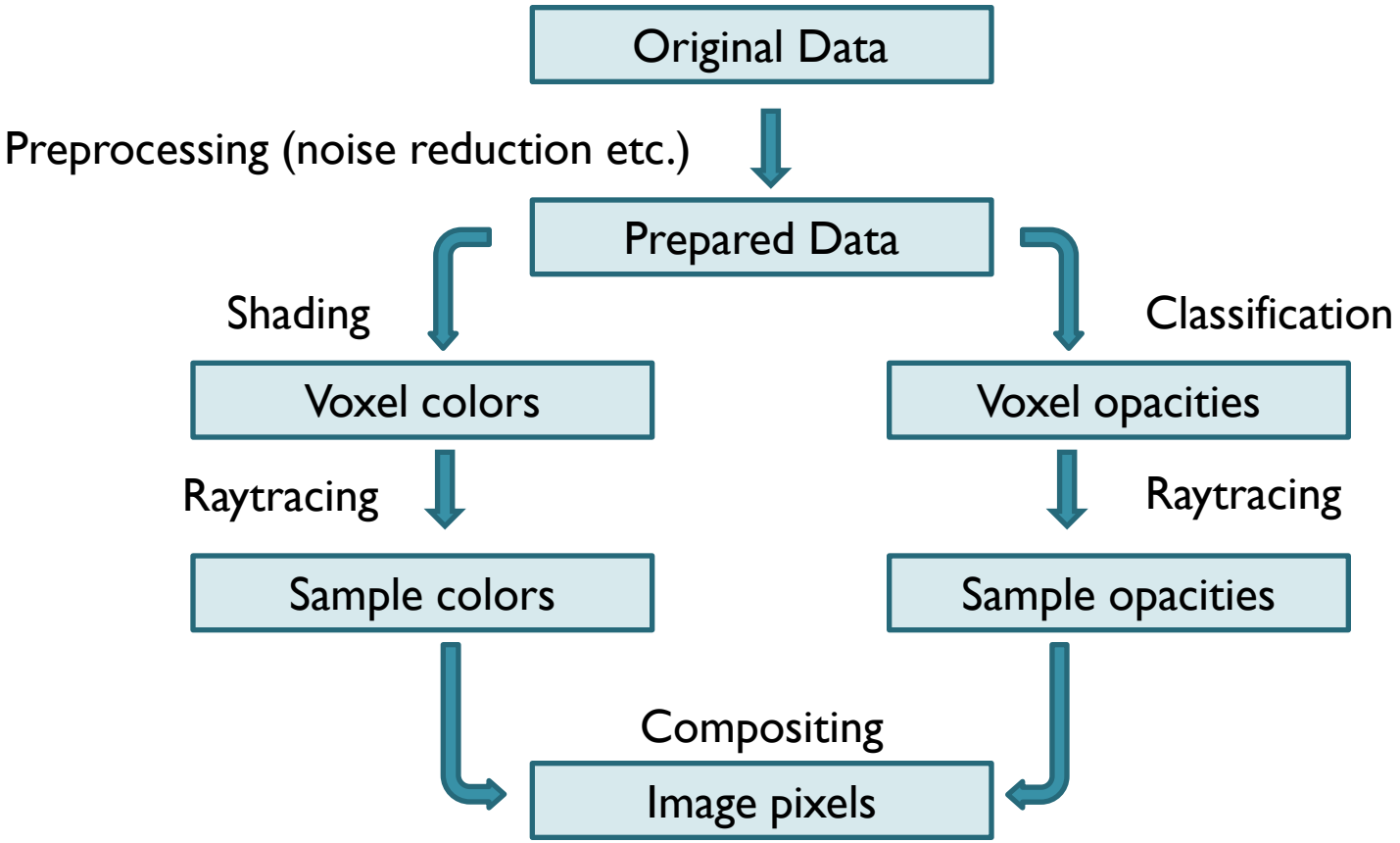
Direct Volume Rendering

- By selecting color and opacity of certain threshold levels, anatomical structures can be vividly reconstructed.



3D Reconstructions of a CT Image via direct volume rendering

Direct volume rendering workflow



Threshold based rendering

- A binary rendering technique (A pixel is within a certain threshold or not)
- An object (tissue etc.) is defined by one or two thresholds
- Threshold can be rendered into surfaces (Isosurface)
- Easy to compute
- Segmentation is essential for further analysis (Volume, shape, intensity…)

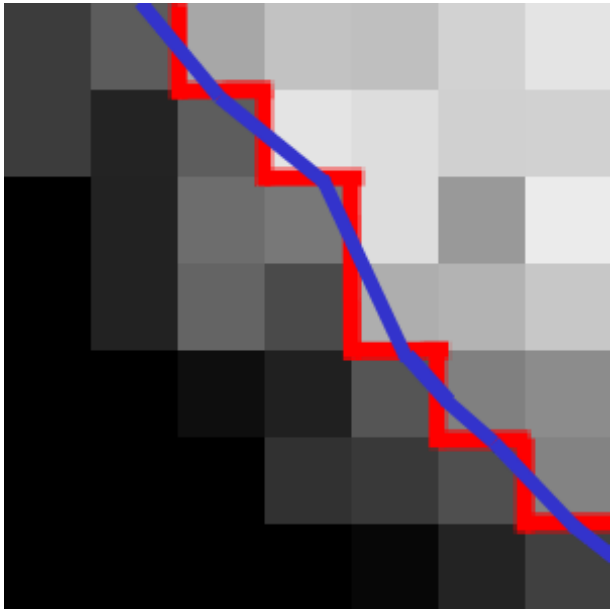
- Disadvantages:
  - A hard threshold is often not accurate because of uneven intensity of structures – fragmented objects, holes
  - Pixels at tissue interfaces cannot be correctly classified

Threshold based rendering

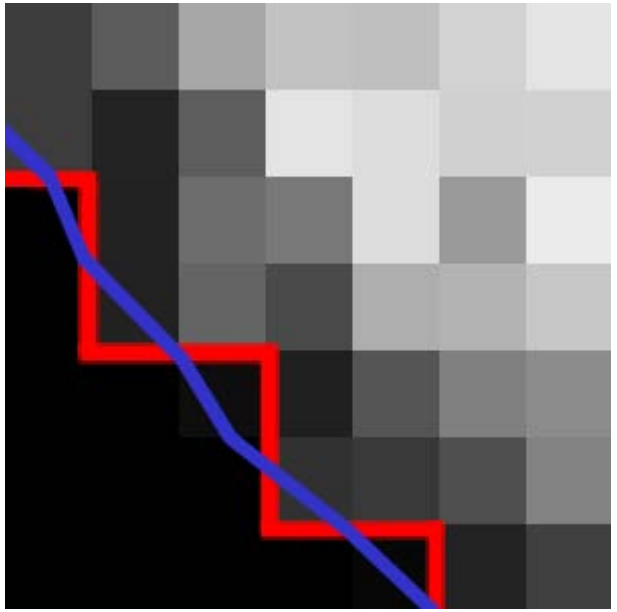
- Threshold is set to a certain brightness value (manual or by algorithms)
- Isosurfaces mark the border between values below and above the threshold
- Algorithms generate reconstruction for smoother appearence

Primary Isosurface

Reconstructed Isosurface



high threshold



low threshold

Threshold based rendering

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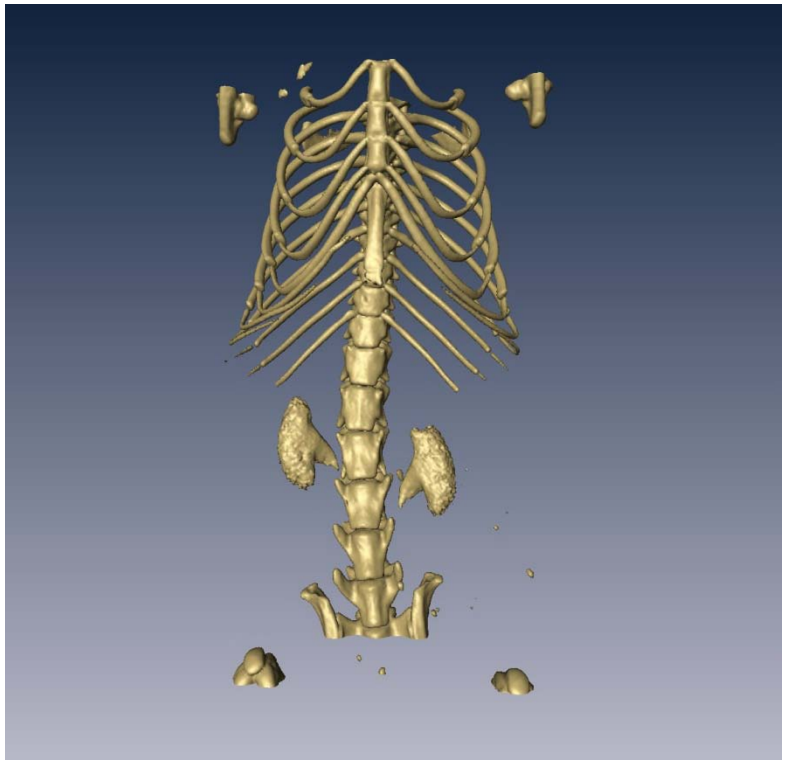
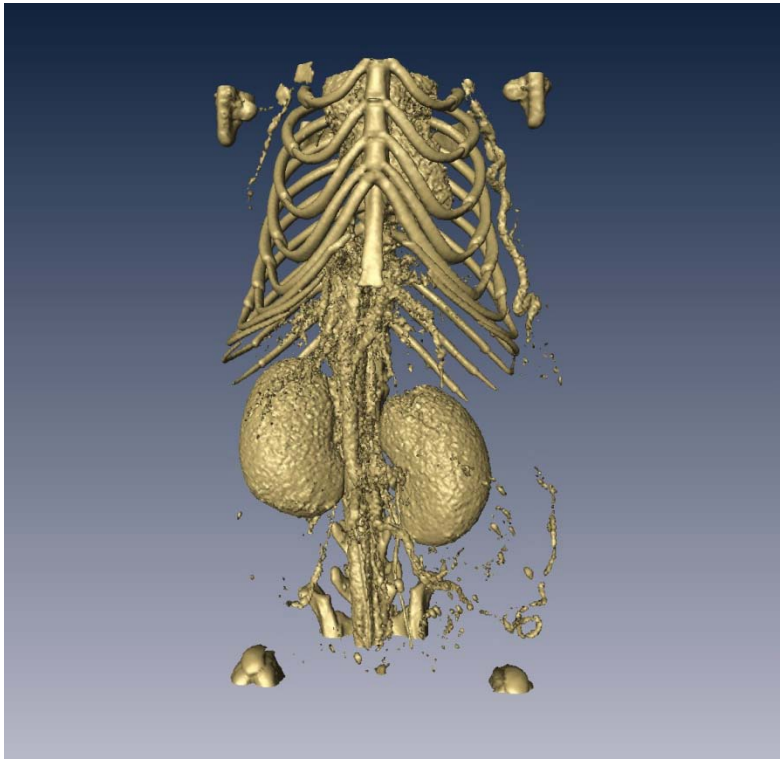
Isosurface Reconstruction

- Chosen threshold value influences the result (shape, volume)!!!
- Smoothing algorythms make a „cleaner“ Image but can bias the result.
- Wireframing is a common reconstruction method



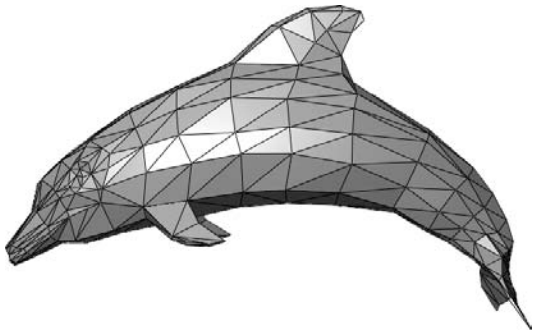
high threshold

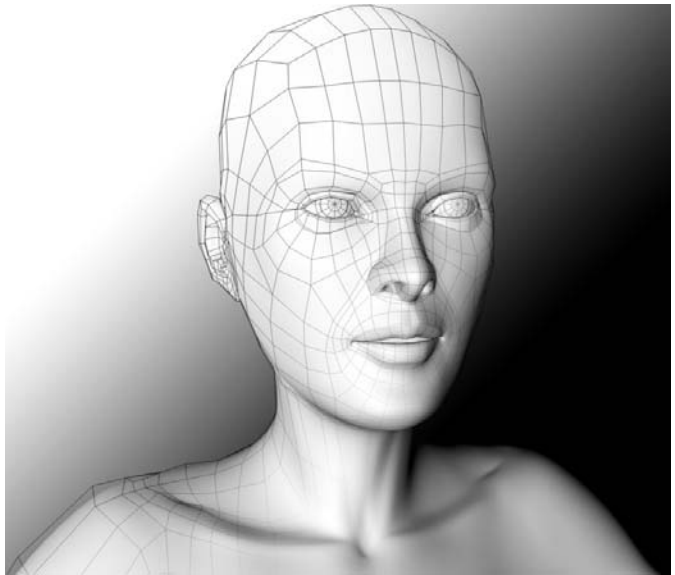


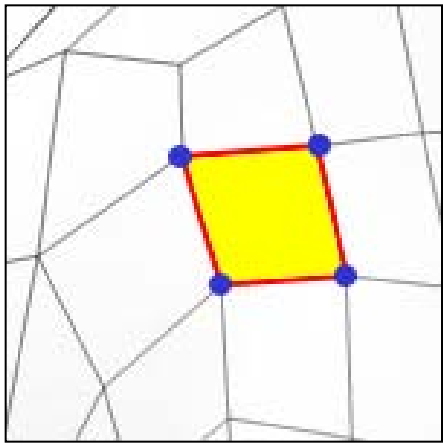
low threshold

Wireframing – Polygonal modeling

- Reconstruction of surface via flat geometrical shapes (polygon meshes)
- Polygons consists of vertices, edge and faces
- Different techniques
  - Marching cubes algorithm: One of the first surface rendering algorithms
  - Newer algorithms for smoothing the mesh







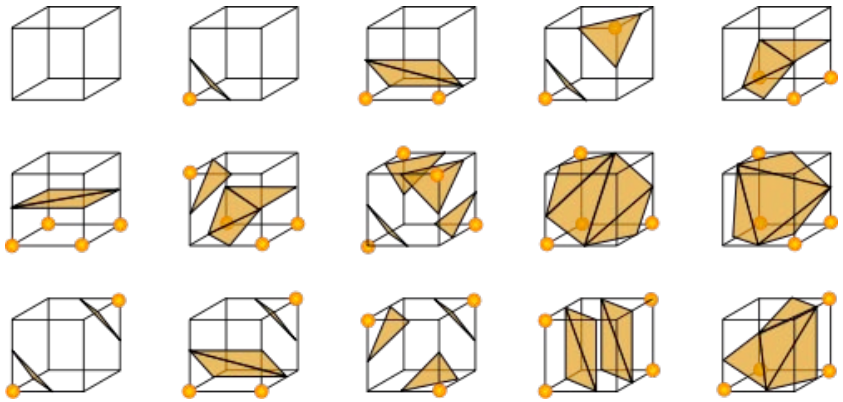
Vertex

Edge

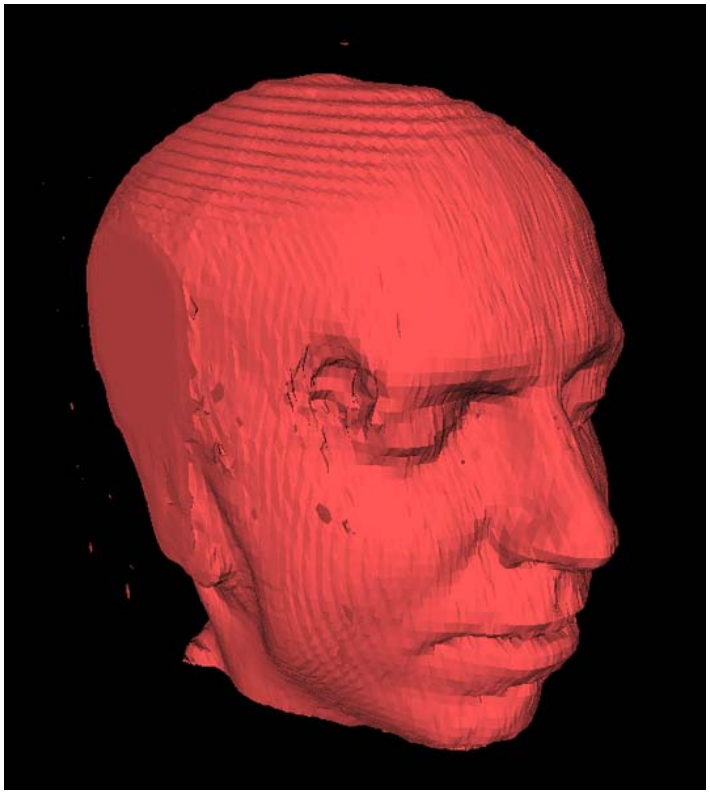
Face

Wireframing – Polygonal modeling

- Marching cubes algorithm:
  - Surfaces are arranged in triangles
  - Algorithm calculates where surface crosses the voxel, „marching“ from one cube to the other.
  - Newer algorithms use other basic Structures.



Possibilities of arranging triangles in certain voxels



Marching cubes surface reconstruction of MRI image

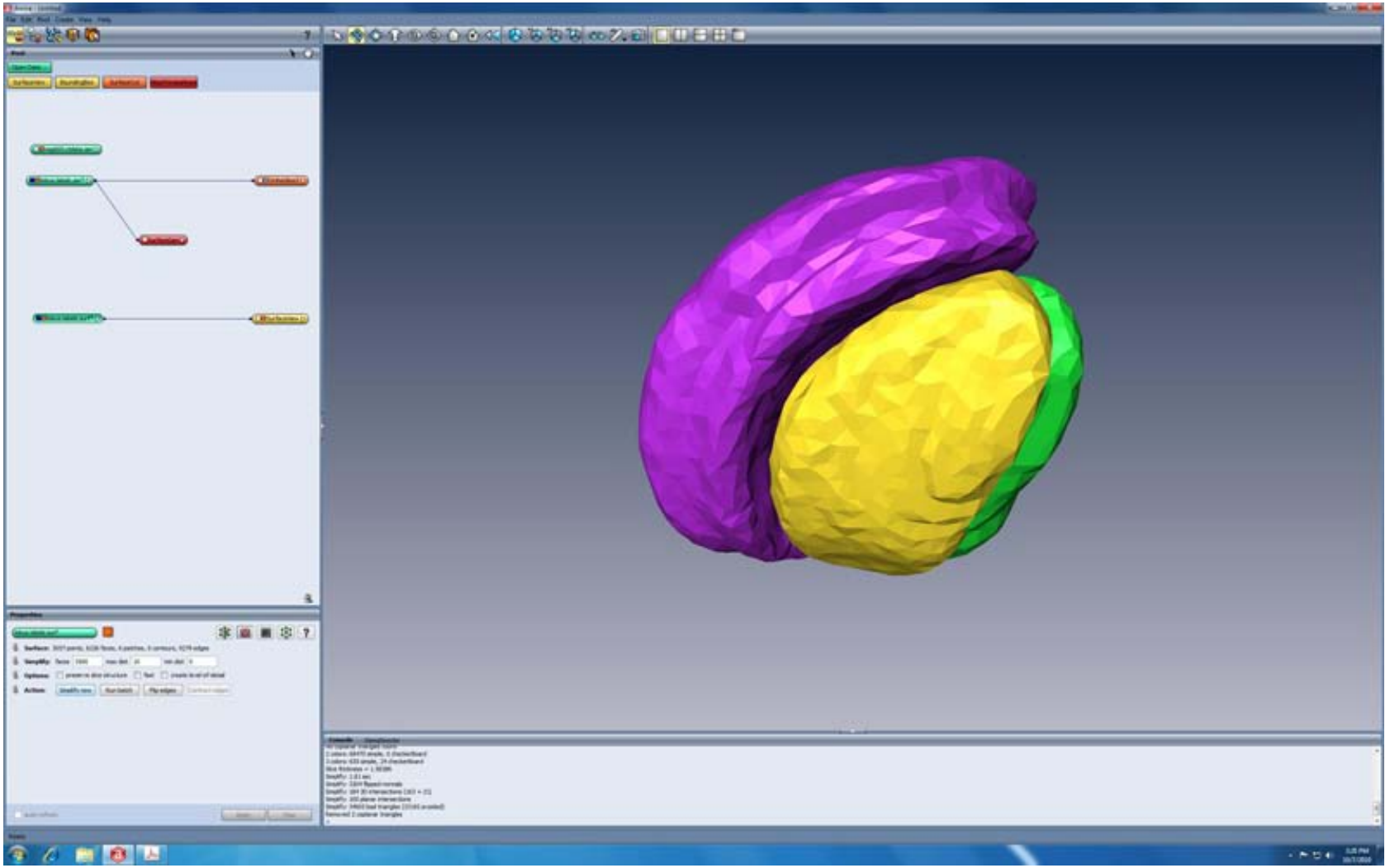
3D rendering software

- Amira
- Imaris
- ImageJ

Amira

- Manufacturer: Visage Imaging
- Qualities: 3D Visualization, analysis and modelling system
- Applicable for medical data analysis as well as biological research and fluid dynamics (Microscopy, CT, MR)
- Modular process pathways
- Different sub programs for special tasks
- VR Option
- Programmable (Matlab)

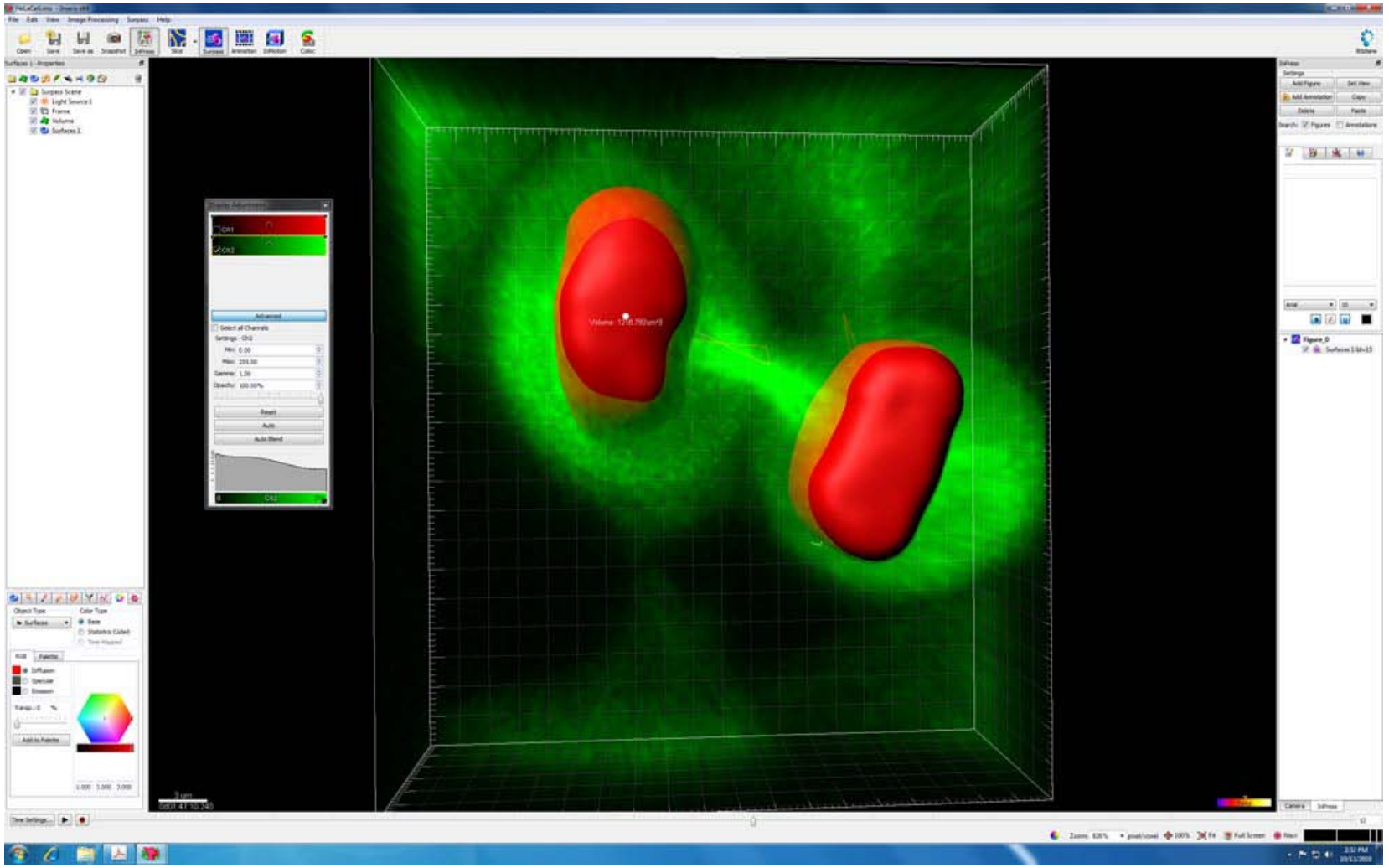
Amira



Imaris

- 3D Visualization, segmentation, analysis and interpretation
- Manufacturer: Bitplane
- Easy to use software for quick results
- Different possibilities for object segmentation
- Colocalization
- Easy and flexible movie creation

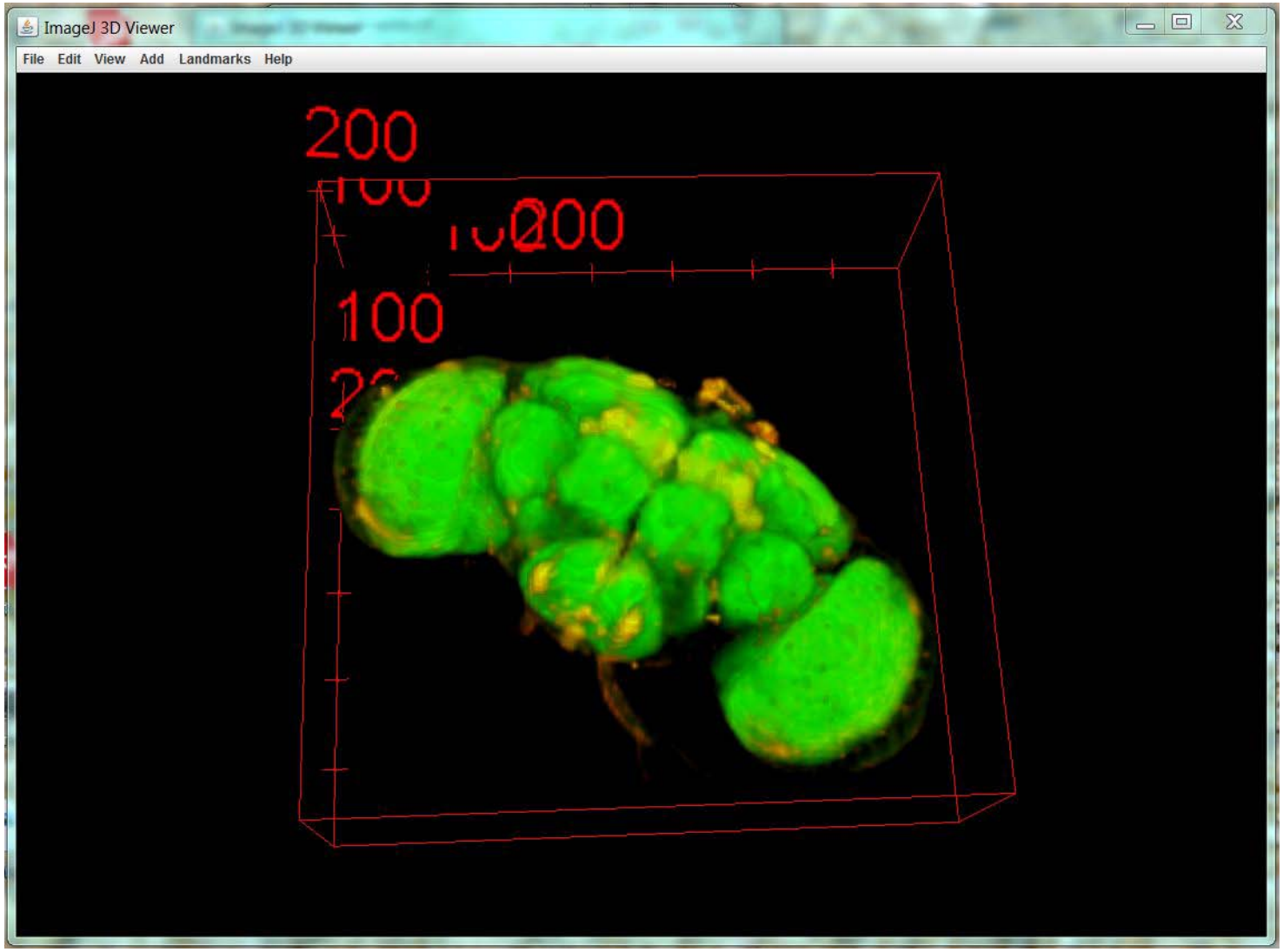
Imaris



Fiji – 3D Viewer

- 3D Visualization, segmentation
- Freeware
- Part of the ImageJ/Fiji environment
- Basic 3D functions for Volume and Surface rendering
- Movie creation
- Expandable with macros and plugins

Fiji – 3D Viewer



Sources

- www.wikipedia.org
- http://fiji.sc
- E. Fishman et al. : Volume Rendering versus Maximum Intensity Projection in CT Angiography: What Works Best, When, and Why
- http://www.cg.tuwien.ac.at/~lidy/vis/algorithm.html