Image Processing
Direct Volume Rendering

Image Processing in SCIRun

IP / DVR

Four primary options:

- Native SCIRun
  - Interpolation
  - Gradient
  - TransformFieldData
- Teem (Nrrd, Gage, Tend, …)
  - N-dim raster data “Swiss Army Knife”
  - Crop, slice, permute
  - Local measures (via Gage and Tend)
- ITK
  - Similar filtering operations to Teem
  - Segmentation filters (threshold, confidence-connected, level sets, …)
  - Registration
- MATLAB

Teem

- Learn “unu” and “tend” (Verbs of Raster Processing)
- Decompose Complex Tasks Into Simple Steps
- Accurate Kernels
  - Derivatives between sample points

Terminal — tcsh (ttyp1)

```
dmw stitch% tend
            --- Diffusion Tensor Processing and Analysis ---
    tend grads ... Calculate balanced gradient directions for DWI acquisition
   tend epireg ... Register diffusion-weighted echo-planar images
    tend bmat ... Calculate B-matrix given gradient directions
   tend estim ... Estimate tensors from a set of DW images
     tend sim ... Simulate DW images from a tensor field
    tend make ... Create DT volume from confidence and eigensystem
   tend helix ... Generate twisting helical tensor field
    tend sten ... Calculate structure tensors from a scalar field
   tend glyph ... Generate postscript or ray-traced renderings of 3D glyphs
  tend ellipse ... Generate postscript renderings of 2D glyphs
   tend anplot ... Graph anisotropy metric in barycentric coords
    tend anvol ... Apply an anisotropy metric to a DT volume
  tend anscale ... Scale the anisotropic component of the tensors
   tend anhist ... Generate barycentric histograms of anisotropy
   tend point ... Describe everything about one sample in a DT volume
   tend slice ... Slice 3D tensors to get slab/image of 3D/2D tensors
   tend fiber ... Extract a single fiber tract, given a start point
    tend norm ... Normalize tensor size
    tend eval ... Calculate one or more eigenvalues in a DT volume
  tend evalpow ... Modify shape by raising eigenvalues to some power
tend evalclamp ... Modify shape by clamping eigenvalues in some range
  tend evaladd ... Modify shape by adding a constant to all eigenvalues
    tend evec ... Calculate one or more eigenvectors in a DT volume
  tend evecrgb ... Make an RGB volume from an eigenvector and an anisotropy
     tend evq ... Quantize directions of diffusion
    tend unmf ... Applies and removes the measurement frame
  tend expand ... Converts a 7-value DT volume to a 9-value DT volume
  tend shrink ... Converts a 9-value DT volume to a 7-value DT volume
    tend bfit ... Non-linear least-squares fitting of b-value curves
   tend satin ... Generate a pretty synthetic DT volume
dmw stitch%
```

Terminal — tcsh (ttyp1)

```
dmw stitch% unu
          --- unu: Utah Nrrd Utilities command-line interface ---
     unu about ... Information about this program and its use
       unu env ... List relevant environment variables and their values
      unu make ... Create a nrrd (or nrrd header) from scratch
      unu head ... Print header of one or more nrrd files
      unu data ... Print data segment of a nrrd file
   unu convert ... Convert to another type (as if by cast, w/ optional clamp)
  unu resample ... Filtering and {up,down}sampling with a seperable kernel
   unu cmedian ... Cheap histogram-based median/mode filtering
    unu minmax ... Print out min and max values in one or more nrrds
  unu quantize ... Quantize values to 8, 16, or 32 bits
unu unquantize ... Recover floating point values from quantized data
   unu project ... Collapse scanlines to scalars along some axis
     unu slice ... Slice at a position along an axis
      unu dice ... Save all slices along one axis into separate files
    unu splice ... Replace a slice with a different nrrd
      unu join ... Connect slices and/or slabs into a bigger nrrd
      unu crop ... Crop along each axis to make a smaller nrrd
     unu inset ... Replace a sub-region with a different nrrd
       unu pad ... Pad along each axis to make a bigger nrrd
   unu reshape ... Superficially change dimension and/or axes sizes
   unu permute ... Permute scan-line ordering of axes
      unu swap ... Interchange scan-line ordering of two axes
   unu shuffle ... Permute slices along one axis
      unu flip ... Reverse order of slices along one axis
  unu unorient ... make image orientation be axis-aligned
    unu axinfo ... Modify attributes of an axis
  unu axinsert ... Add a "stub" (length 1) axis to a nrrd
   unu axsplit ... Split one axis into two axes
  unu axdelete ... Remove one or more singleton axes from a nrrd
   unu axmerge ... Merge two adjacent axes into one
      unu tile ... Tile slices of one axis into two other axes
    unu untile ... Undo "unu tile": merge slow parts of two axis splits
     unu histo ... Create 1-D histogram of values in a nrrd
    unu dhisto ... Create (PGM) image of 1-D value histogram
    unu jhisto ... Create joint histogram of two or more nrrds
    unu histax ... Replace each scanline along an axis with its histogram
       unu heq ... Perform histogram equalization
     unu gamma ... Brighten or darken values with a gamma
       unu 1op ... Unary operation on a nrrd
       unu 2op ... Binary operation on two nrrds, or on a nrrd and a constant
       unu 3op ... Ternary operation on three nrrds or constants
       unu lut ... Map nrrd through one univariate lookup table
      unu mlut ... Map nrrd through whole nrrd of univariate lookup tables
     unu subst ... Map nrrd through a univariate substitution table
      unu rmap ... Map nrrd through one *regular* univariate map ("colormap")
     unu mrmap ... Map nrrd through a whole nrrd of regular univariate maps
      unu imap ... Map nrrd through *irregular* univariate map ("colormap")
      unu lut2 ... Map nrrd through a bivariate lookup table
    unu ccfind ... Find connected components (CCs)
     unu ccadj ... Form adjecency matrix of connected components
   unu ccmerge ... Merge CCs with their neighbors, under various contraints
  unu ccsettle ... Remap CC values down to lowest contiguous values
      unu save ... Write nrrd with specific format, encoding, or endianness
dmw stitch%
```

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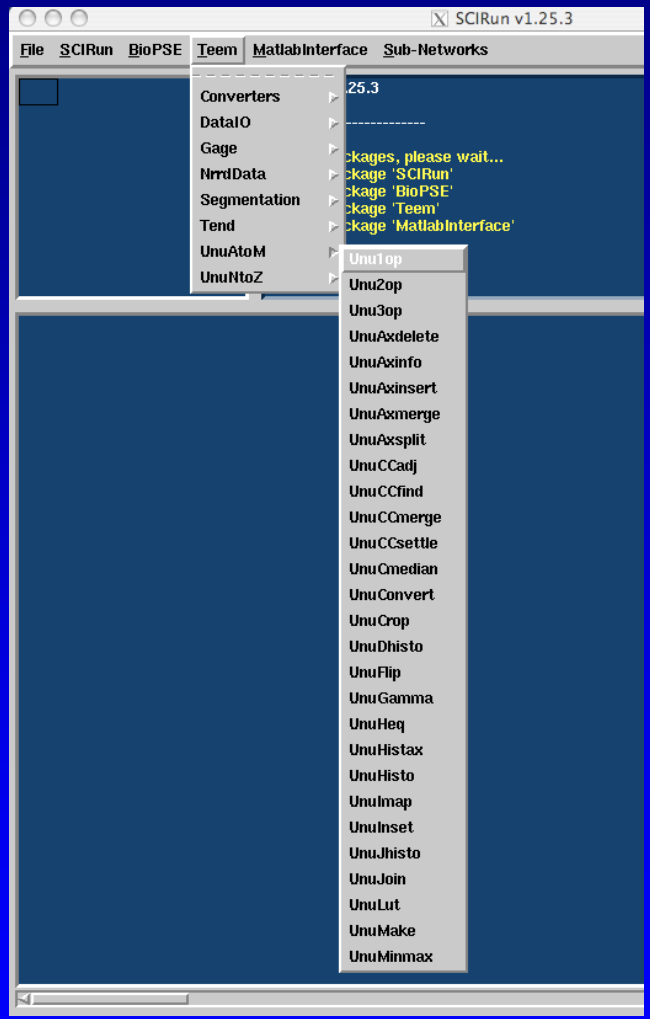
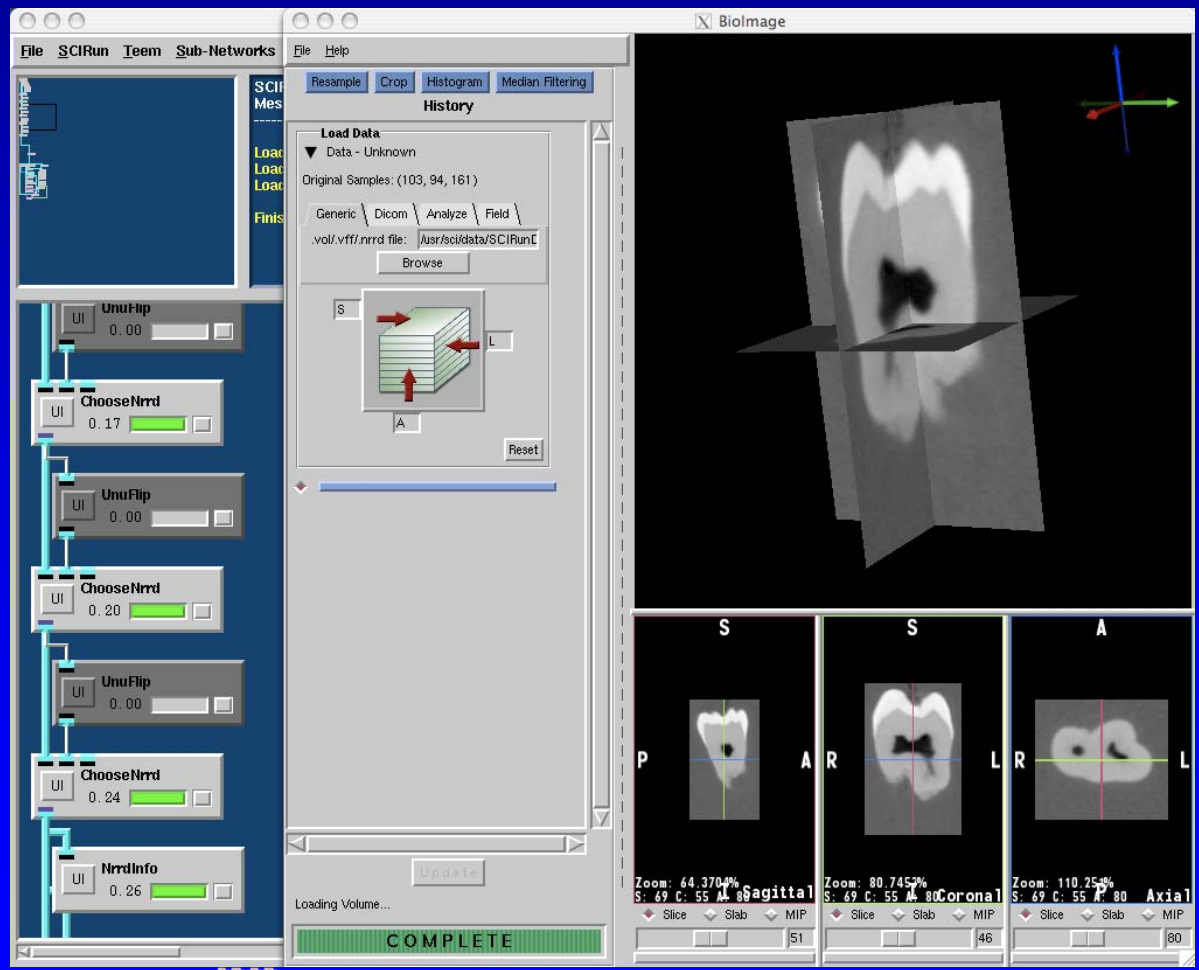
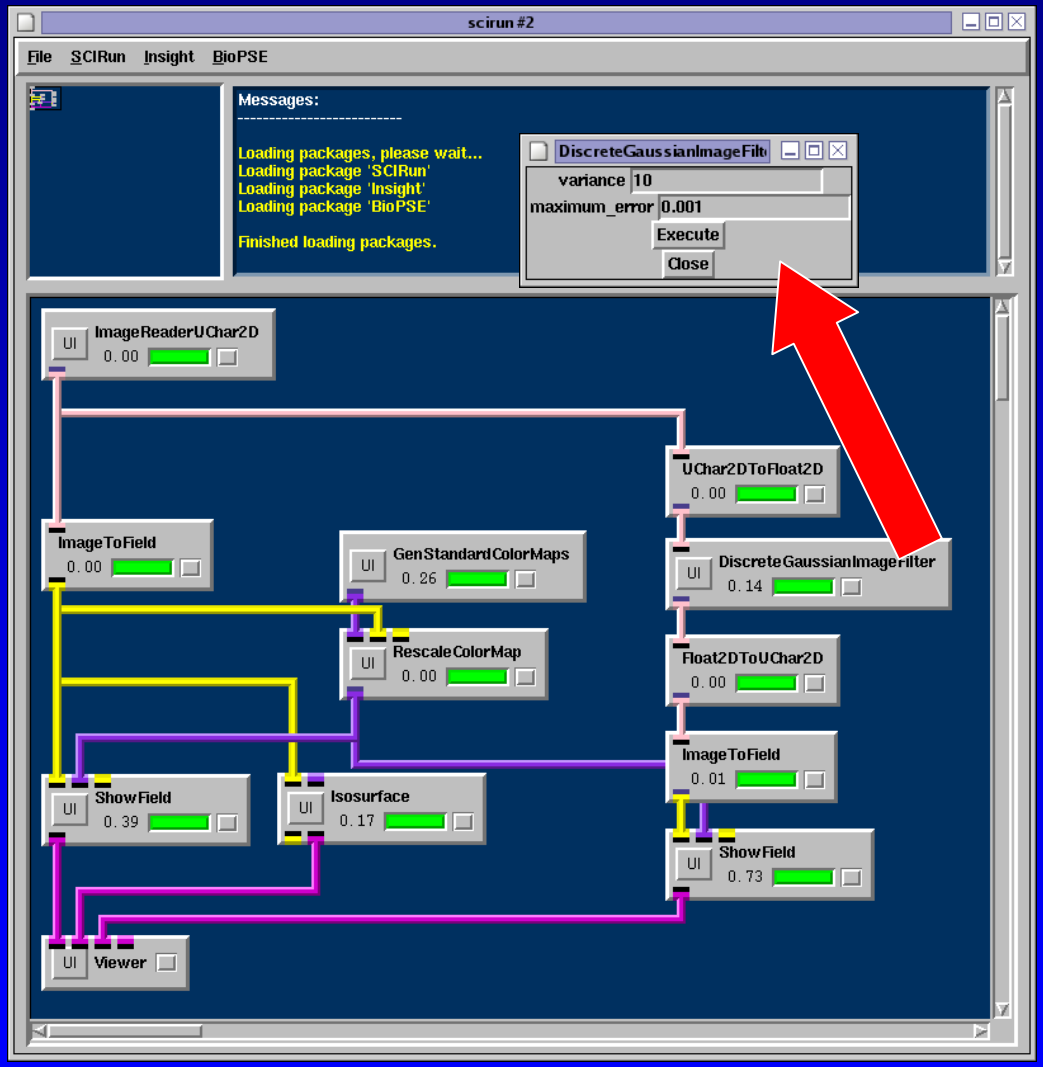
Teem in SCIRun

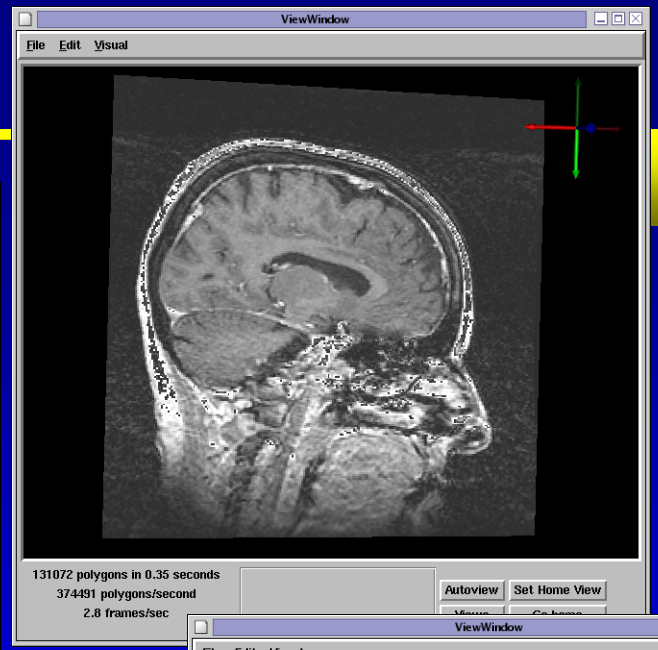
IP / DVR



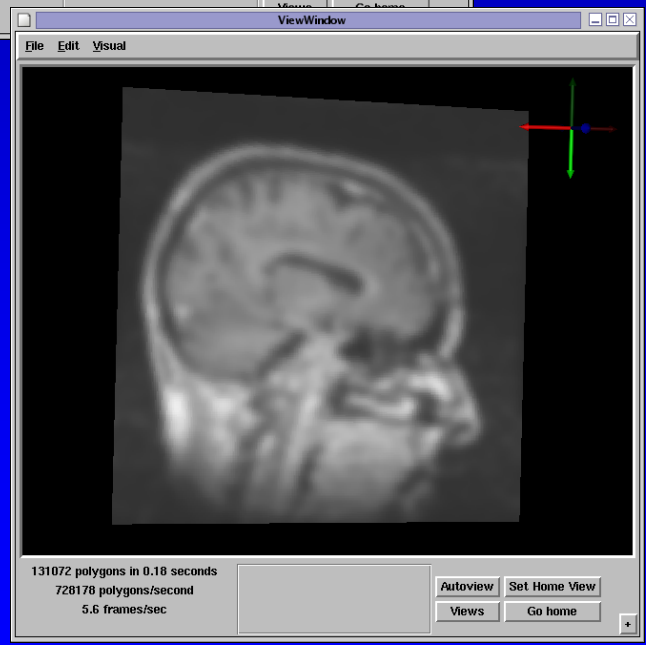


ITK in SCIRun





DVR



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CIBC

Direct Volume Rendering

IP / DVR

Multi-dimensional Transfer Functions

- Boundaries
- BioImage

More Examples

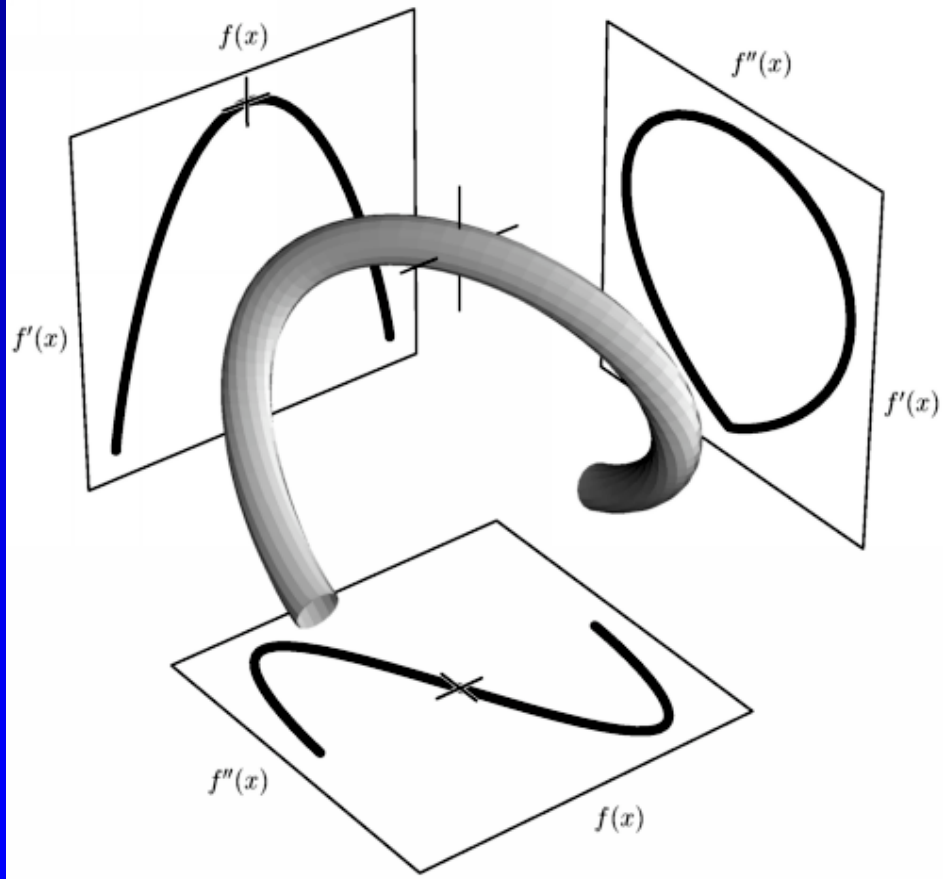
SCIRun Volume Rendering Modules

Gordon Kindlmann's MS Thesis

Semi-Automatic Generation of Transfer Functions for Direct Volume Rendering

Gordon Kindlmann

A Thesis Presented to the Faculty of the Graduate School of
Cornell University
in Partial Fulfillment of the Requirements for the Degree of
Master of Science



Boundaries

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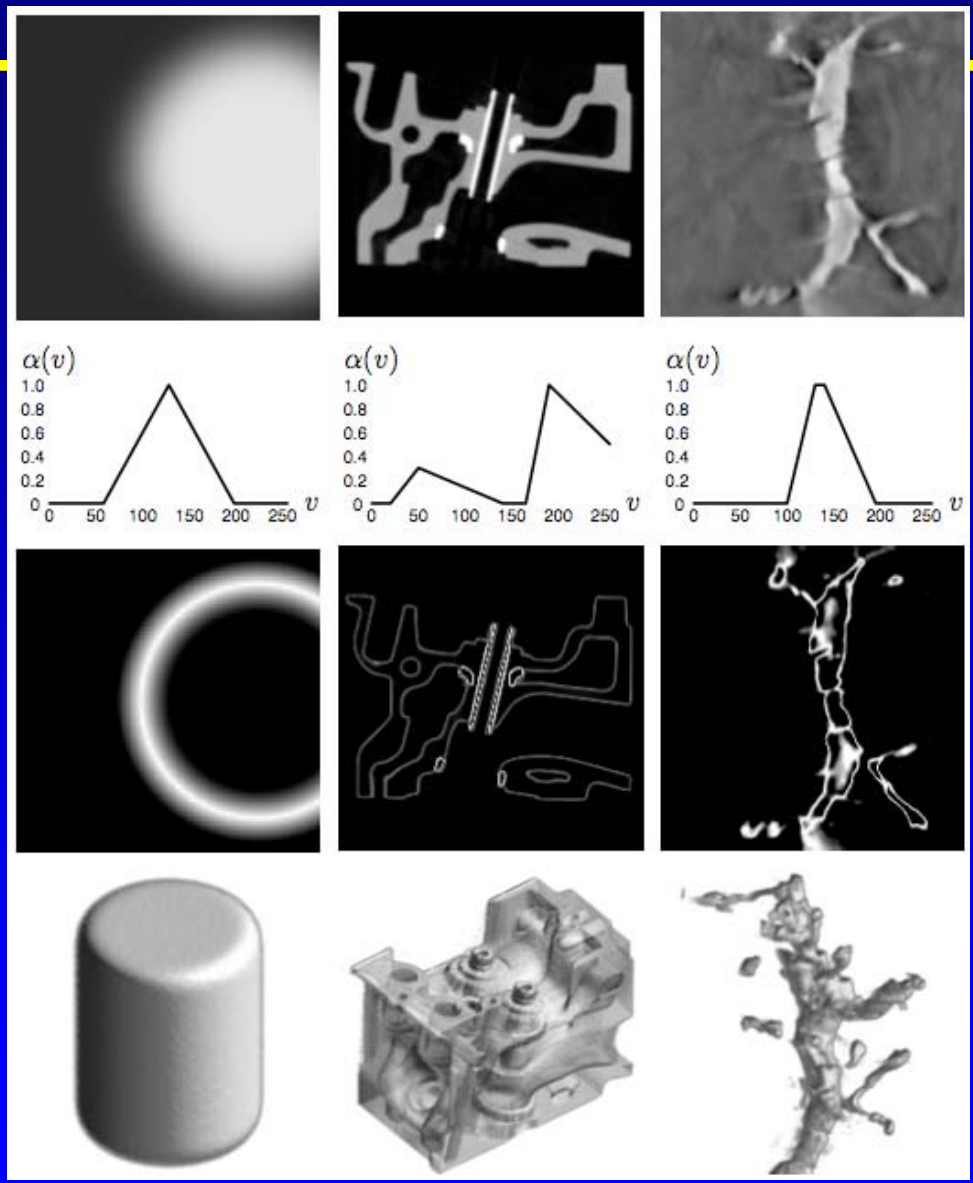
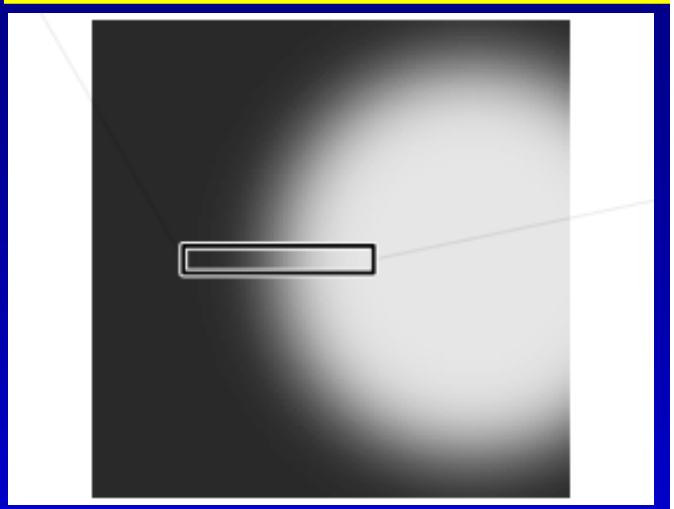
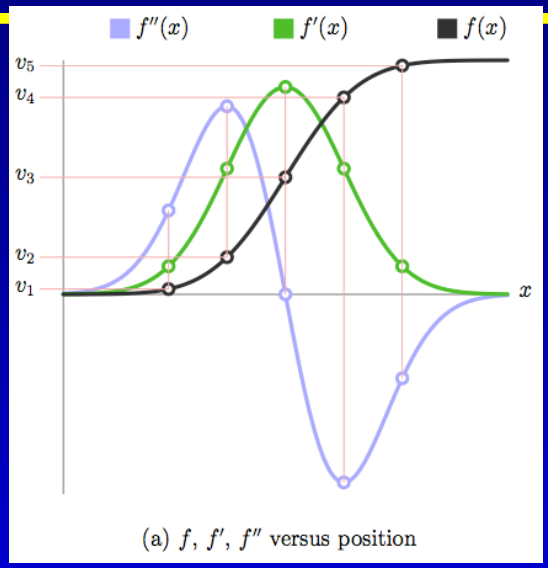
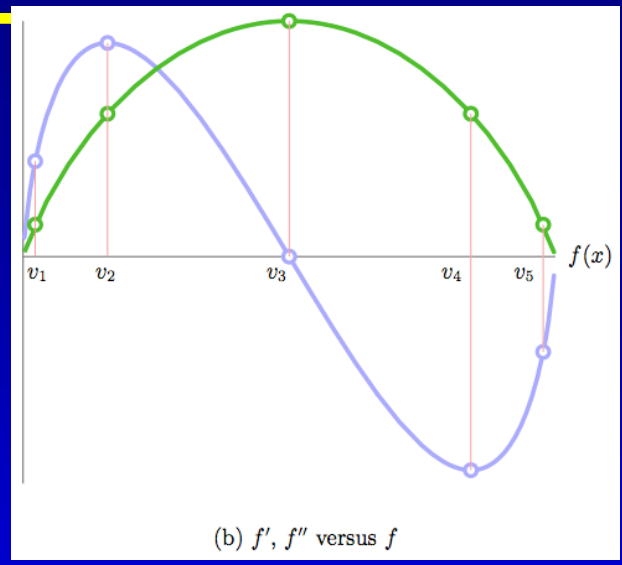


Boundaries

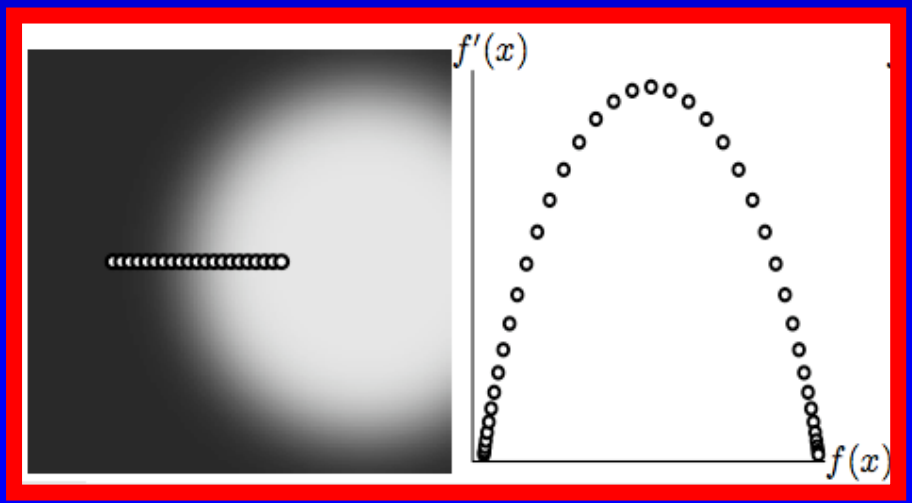


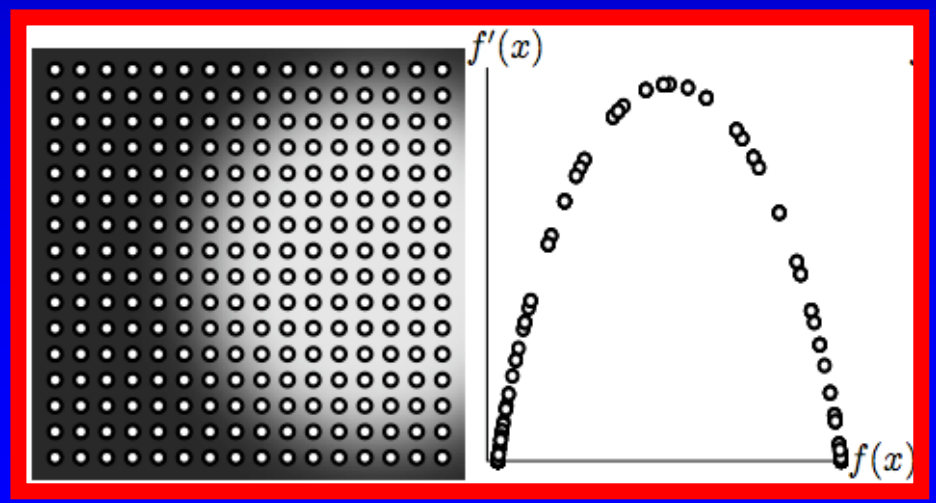


(a) f, f', f'' versus position



(b) f', f'' versus f





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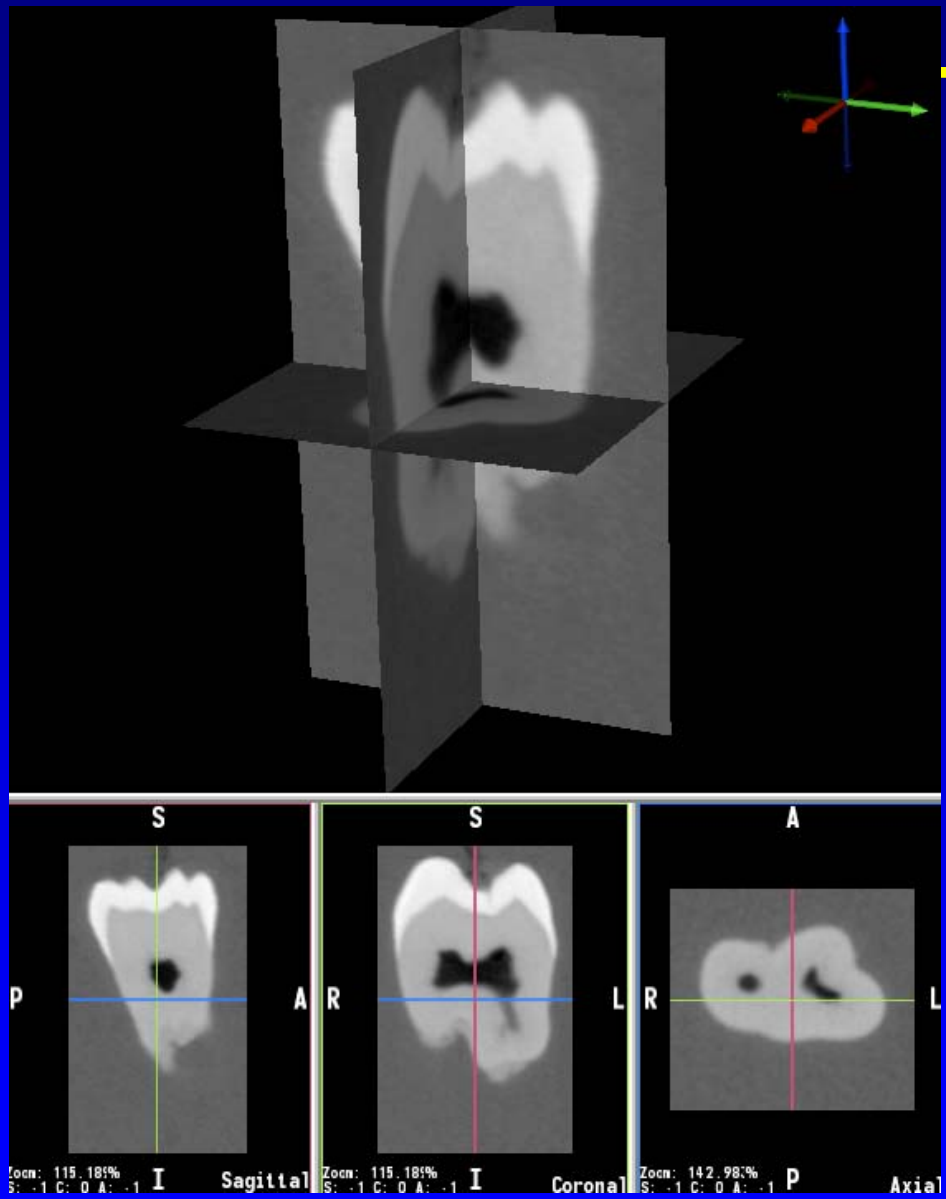

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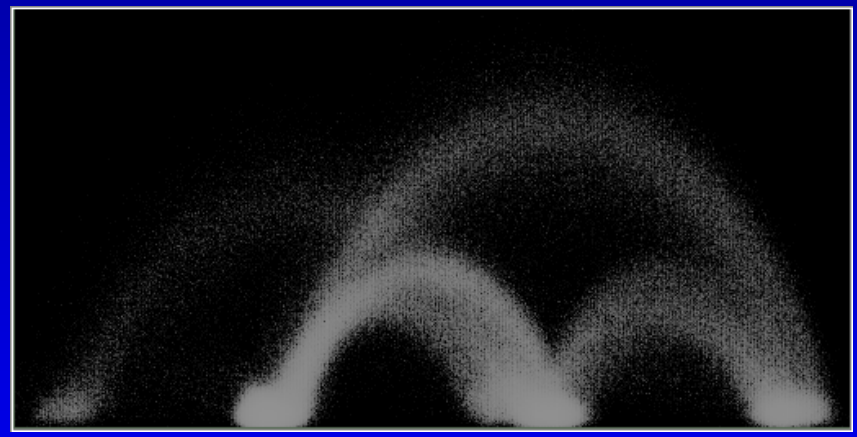

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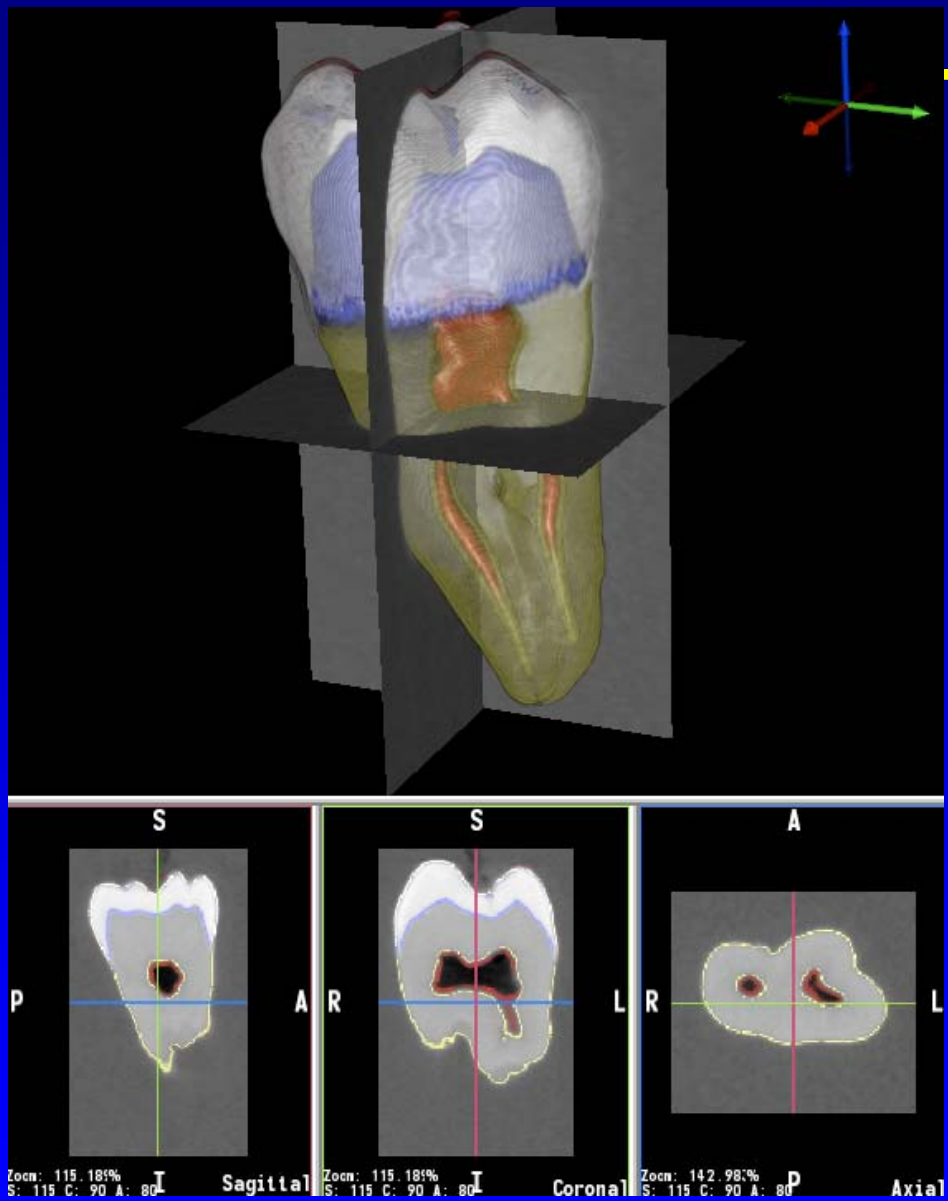

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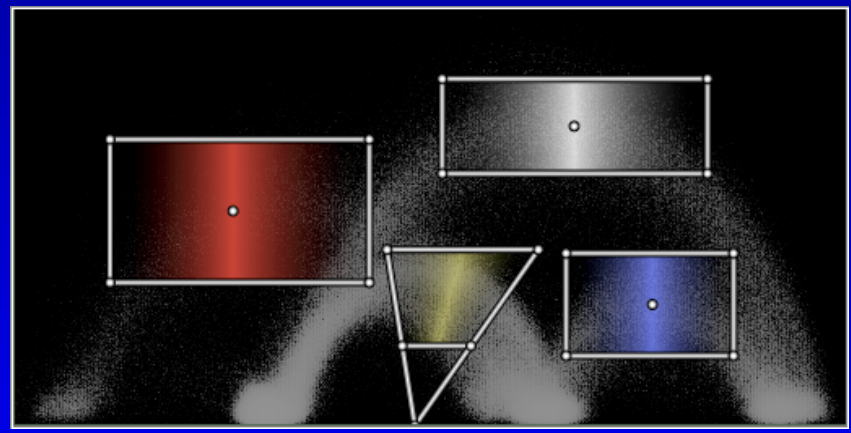

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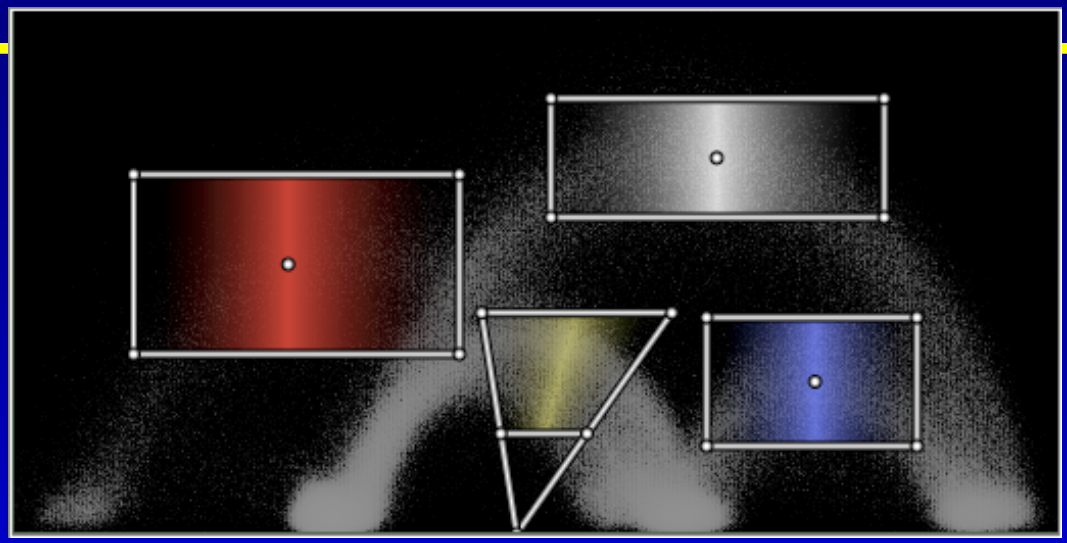

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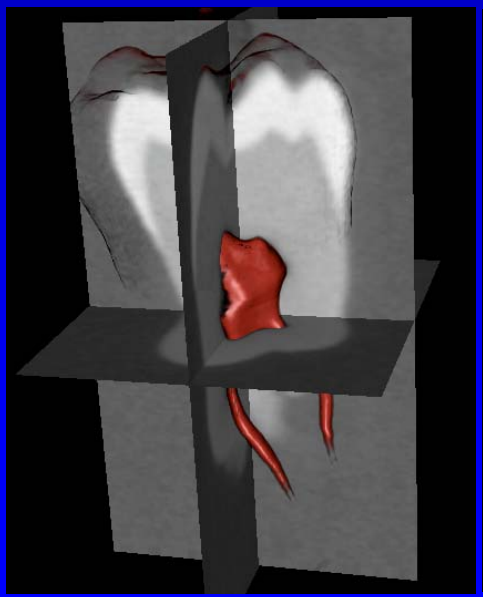

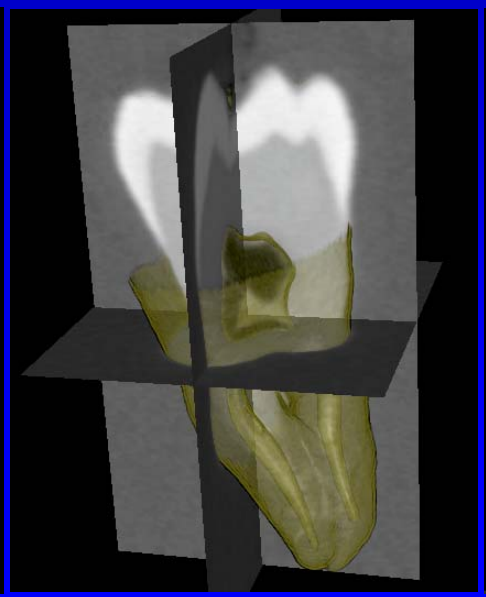

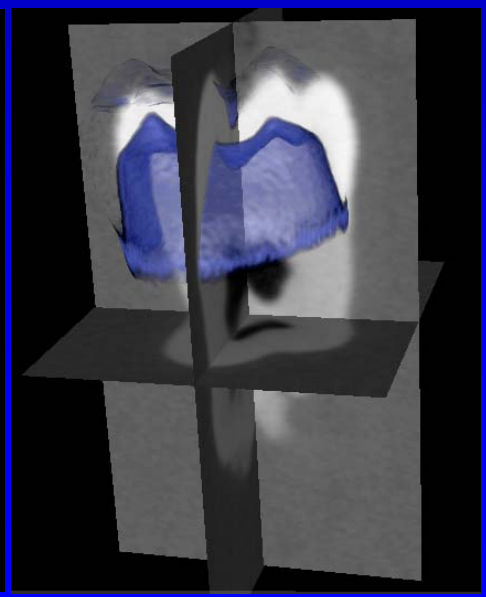

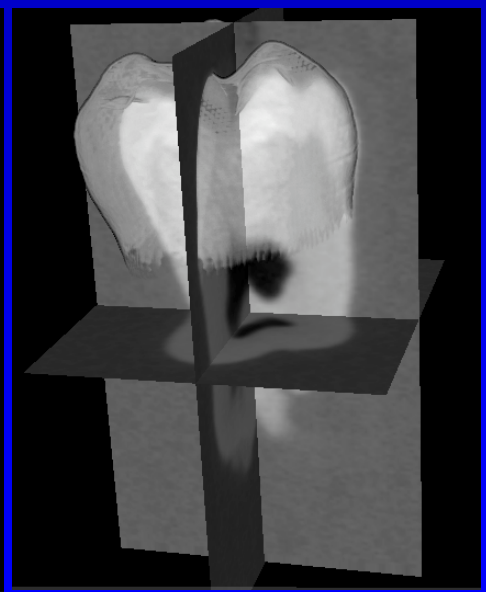

Tumor Vessel Imaging and Visualization

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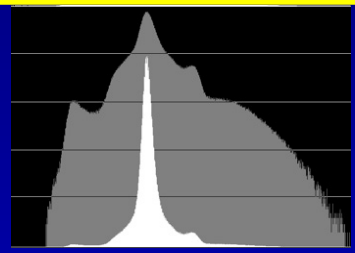

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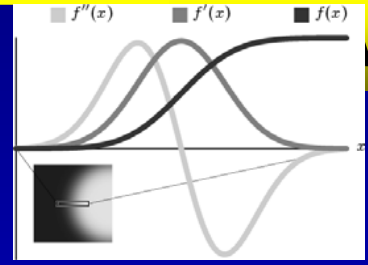


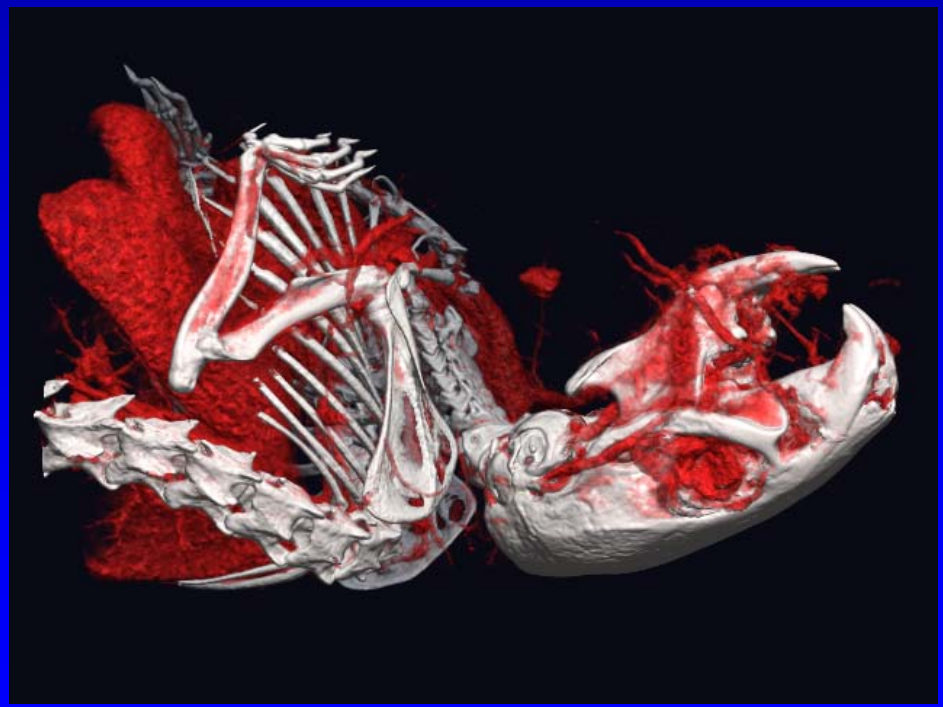
VR

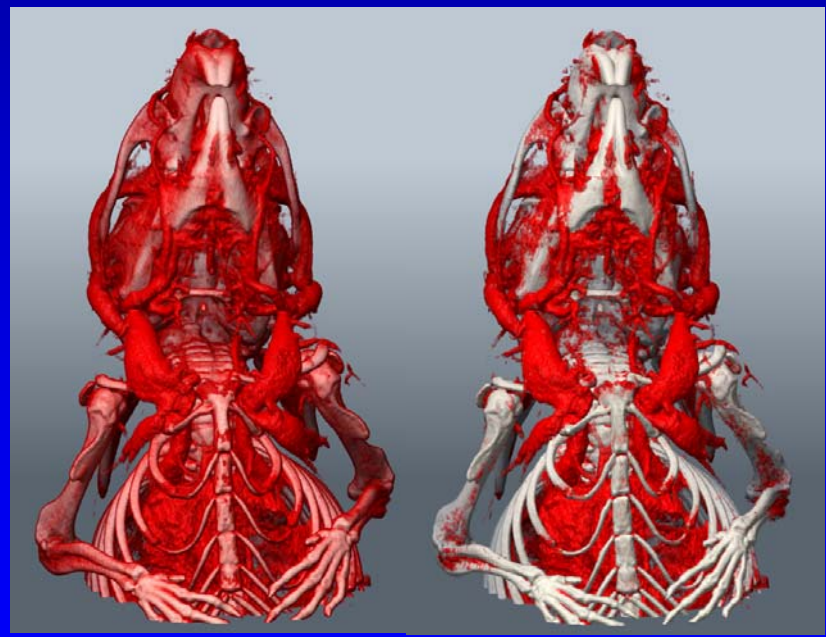
Immobilize.
Dose Contrast

Optimize
Signal : Noise vs Time

Discern Contrast

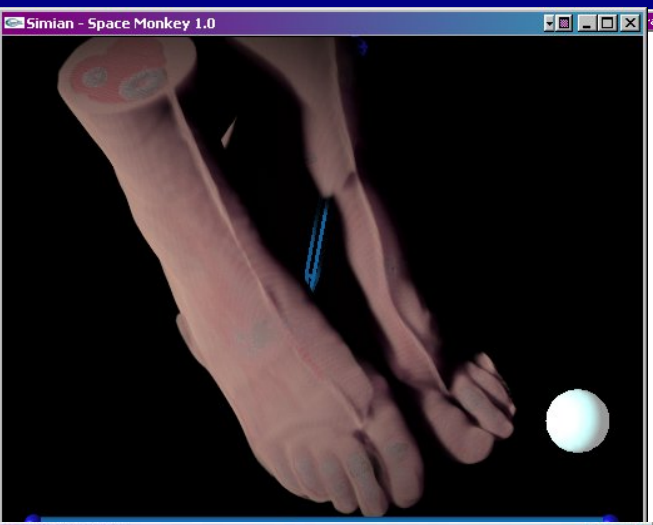
Detect Boundaries

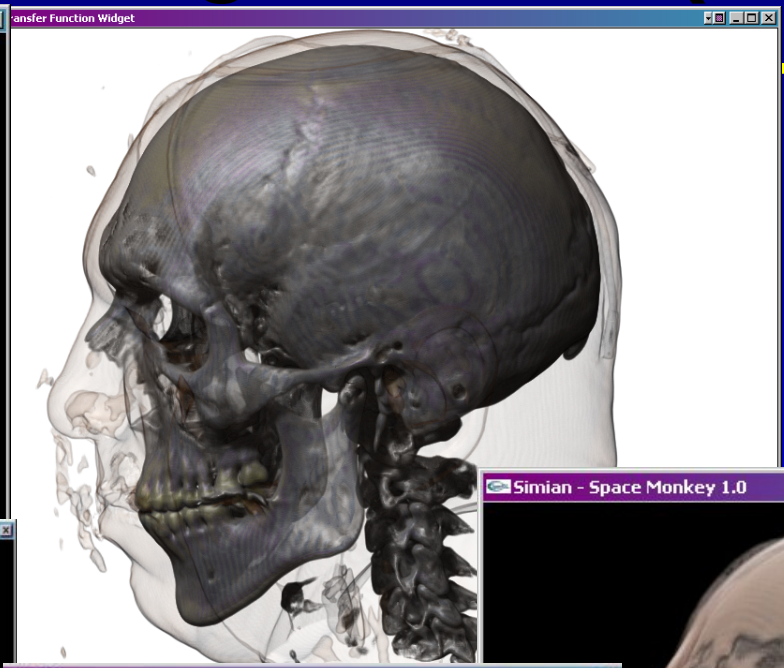




G. Kindlmann, D. Weinstein, G. Jones, C.R. Johnson, M. Capecchi, and C. Keller. Practical Vessel Imaging by Computed Tomography in Live Transgenic Mouse Models for Human Tumors, *Journal of Molecular Imaging*, 2005.

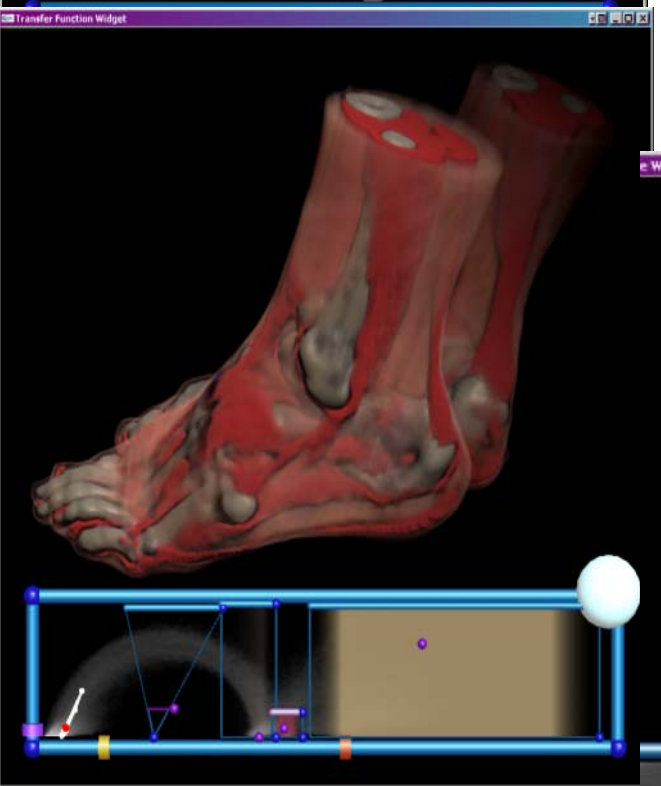
Volume Rendering: SIMIAN (Joe Kniss)

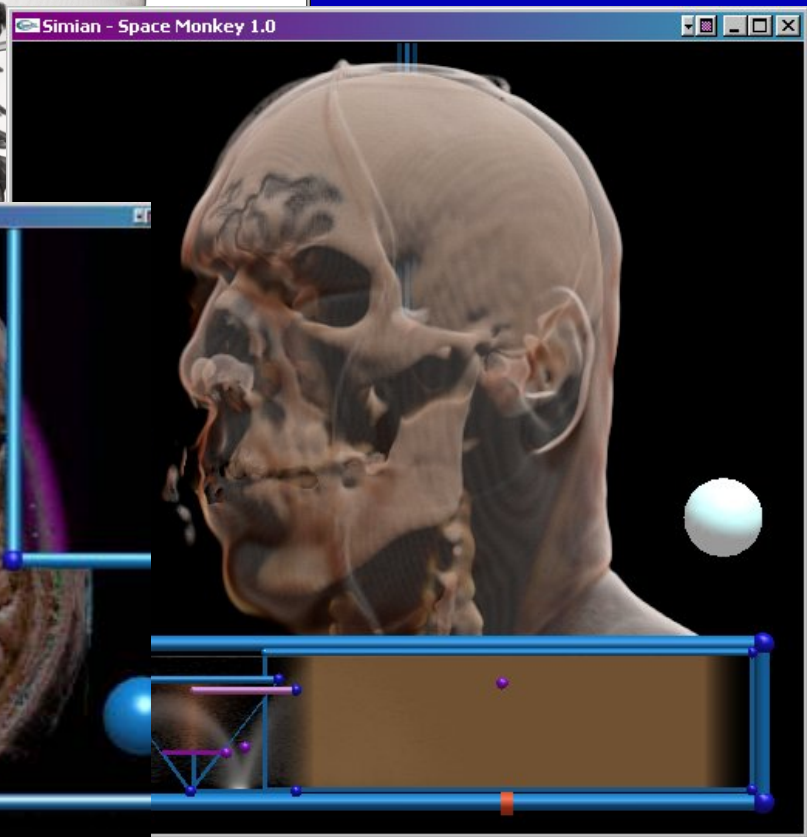




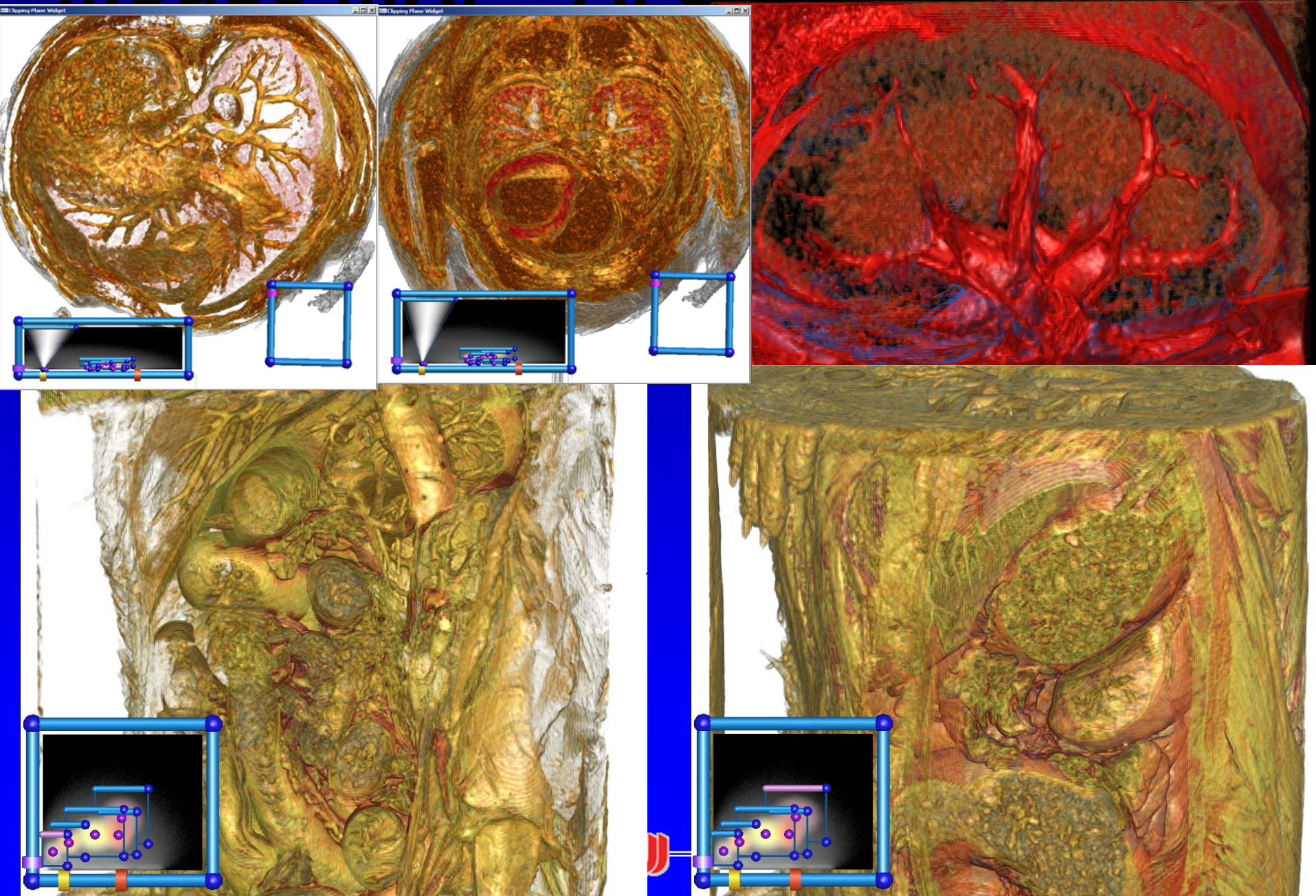
IP / DVR

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.





Mouse MRI – Al Johnson - Duke

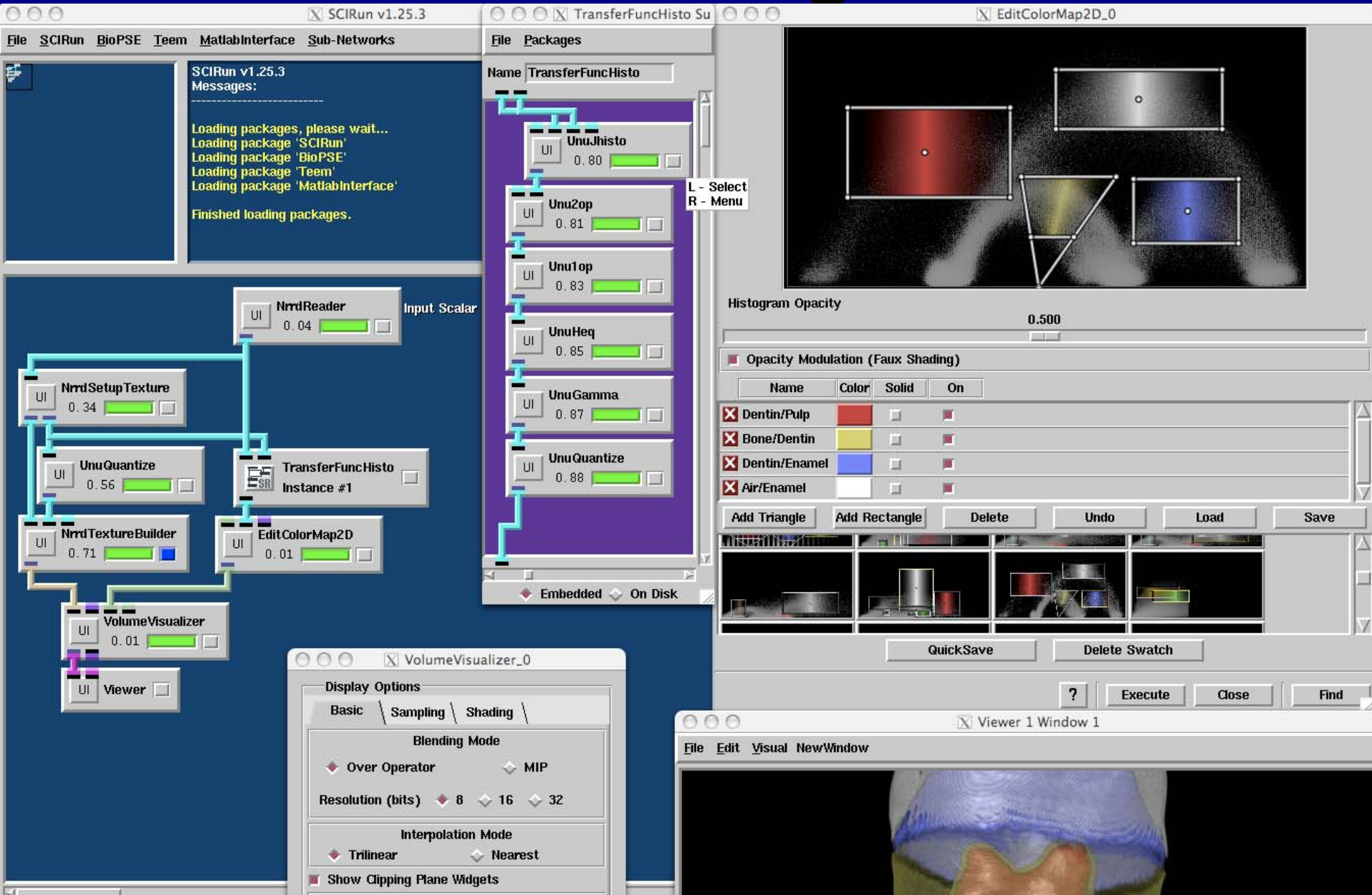


Volume Rendering in SCIRun

IP / DVR

- Texture Objects
- Gradients
- Slice Rendering
  - Axis aligned
  - Tangent to view direction
- Volume Rendering
  - Slice based
  - MIP (max operator)
  - “Direct volume rendering” (over operator)

Volume Rendering in SCIRun



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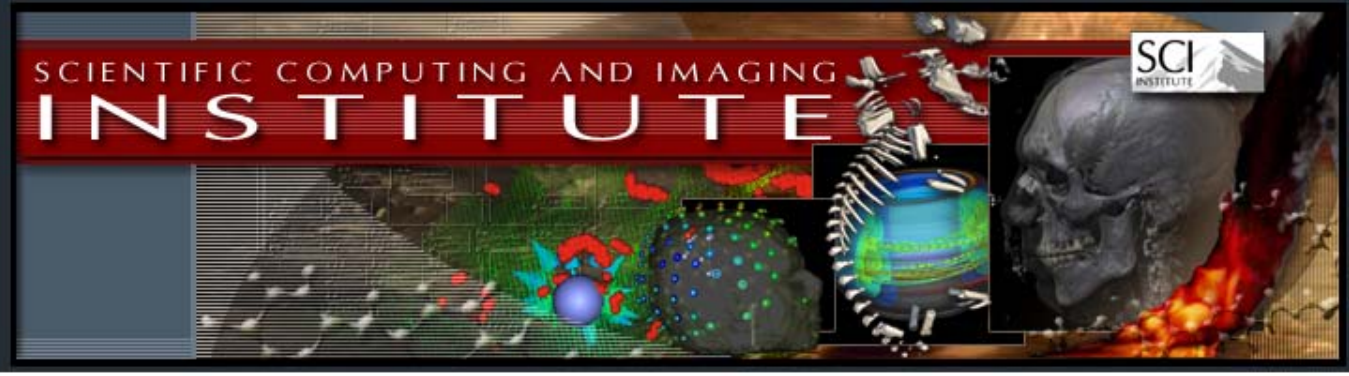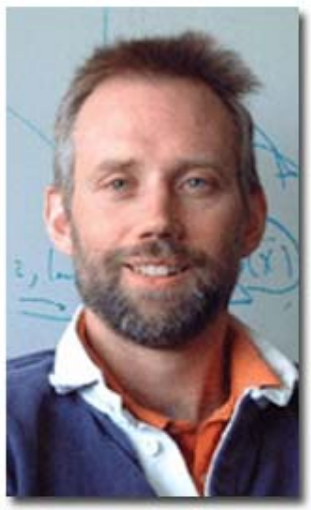
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