Spatialized Transfer Functions

EuroVis '05

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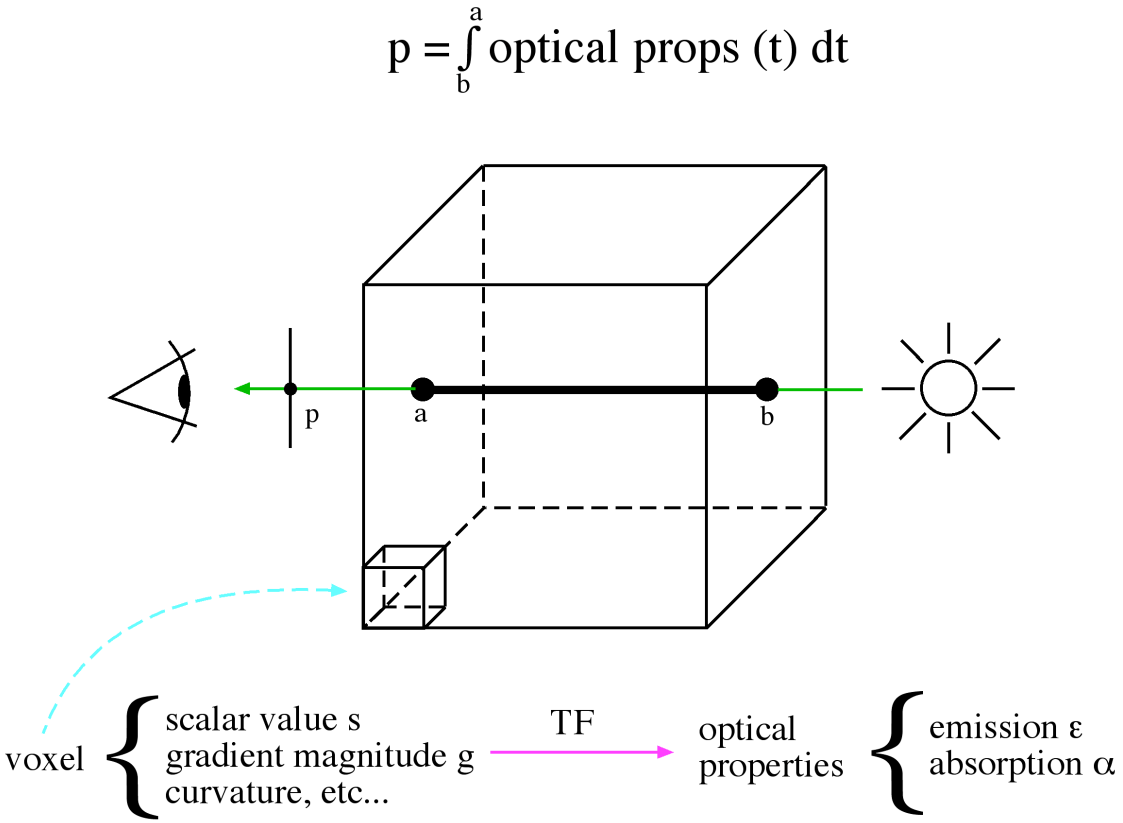
Overview

- Introduction: Direct Volume Rendering with Multi-dimensional Transfer Functions
- Problems of Traditional TF Setup
- Generating a STF (Spatialized Transfer Function)
- Practical Examples from Medical Visualization

Direct Volume Rendering

- TF(s) : 1D
- TF(s, ...) : multi-dimensional
  Kindlmann '98
- TF(s,g) : 2D
- TF(s_{CT},s_{MR}) : 2D registered



TF Setup

- Simplest case is a 1D TF with zero emission and linear absorption which corresponds to X-Ray images
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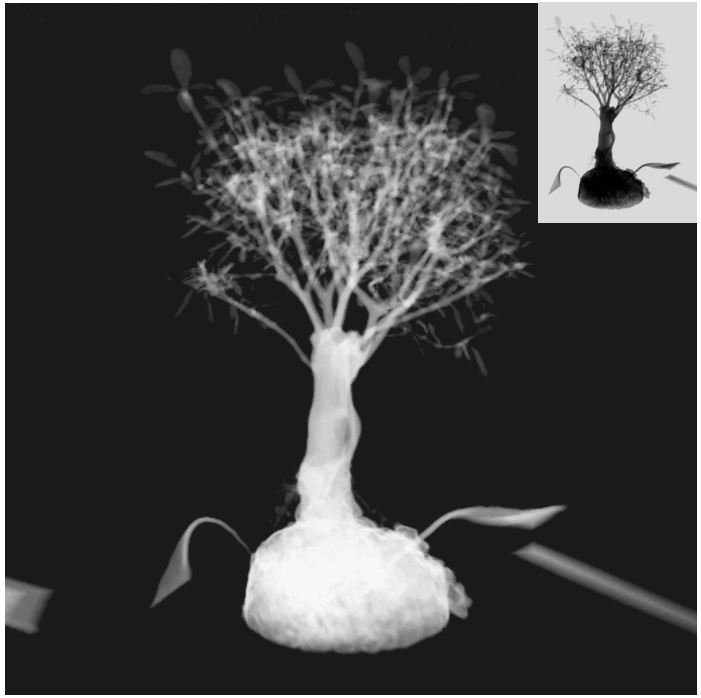
- Challenge: determine TF so that we get a useful image

  e.g. color the leaves green
- Problem: 1D TF are often too limited to yield good results
- So we better switch to higher-dimensional TF



X-Ray Negative of a Bonsai

2D TF Setup

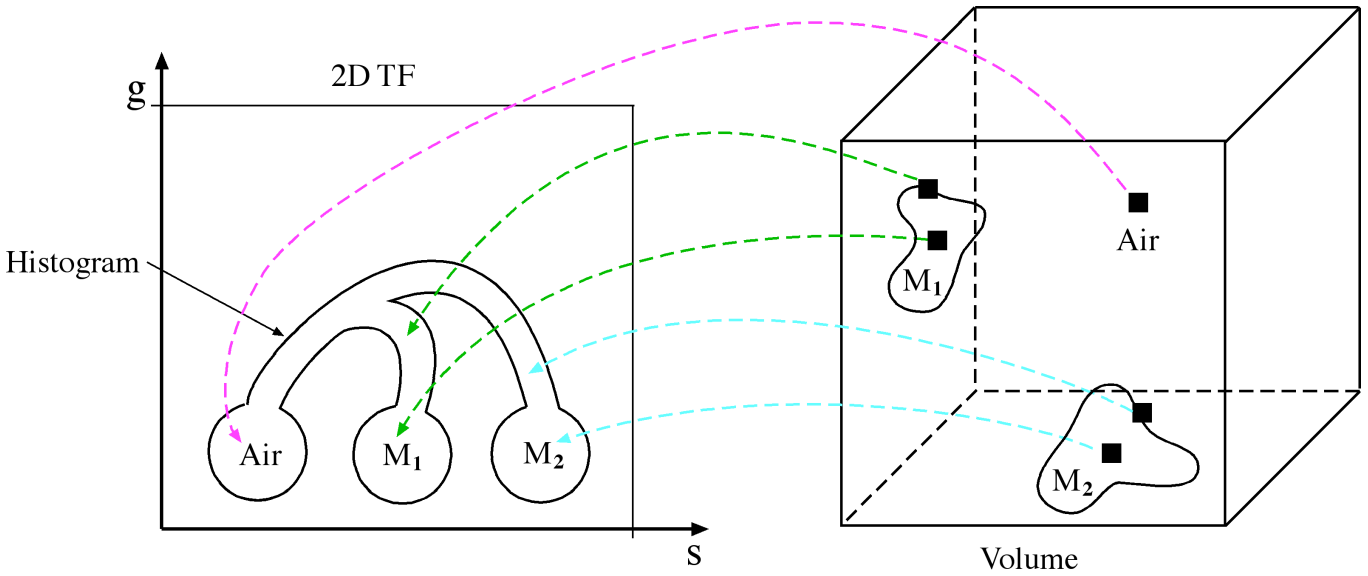
- 2D TF are useful but difficult to setup (paint)

  Main problem: which region in the TF corresponds to a specific structure in the volume

  Kniss '01: guidance by point probe

- Need a (semi-)automatic setup procedure

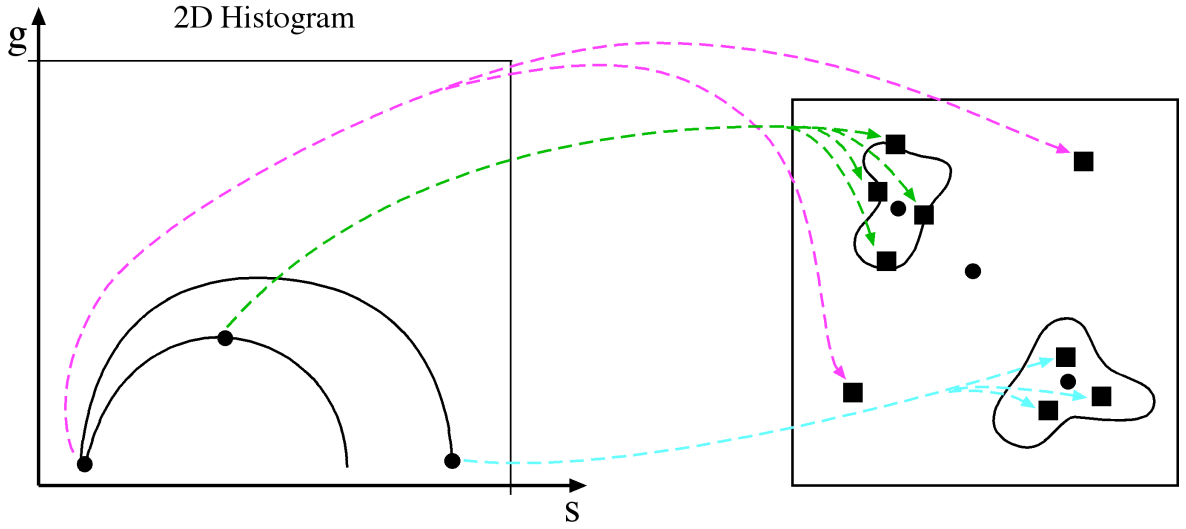
  Goal: assign each distinct structure a specific color



Our Approach

- Each entry in the TF corresponds to a set of voxels the spatial distribution of which is specific for each structure
- In order to separate structures all entries with a similar spatial voxel distribution should be colored uniquely

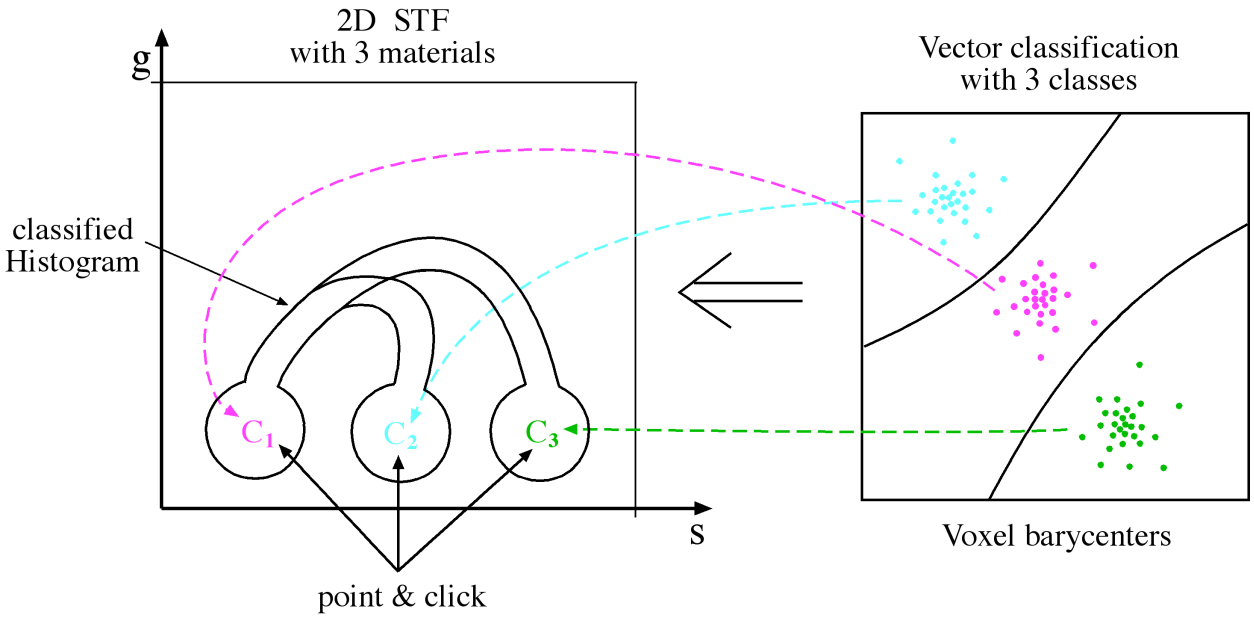
  This is achieved by performing a vector classification of the domain of the TF with respect to the spatial voxel distribution which is characterized by the voxel barycenters and the variance



STF Setup

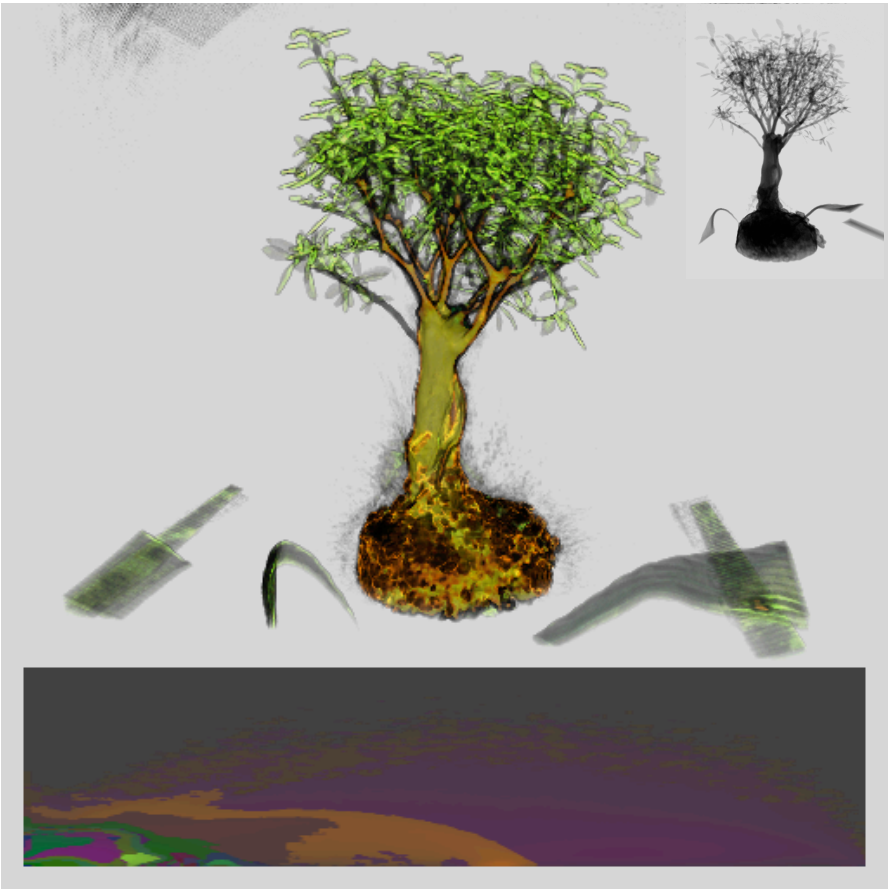
- Precalculate all barycenters: then the computation of a vector classification with n classes takes <200ms
- Derive STF by assigning a random color to each class

  The users task is to adjust n interactively (could be automatic)
- Optionally select interesting structures by pointing & clicking into the STF (toggles opacity for one class)



Bonsai Example

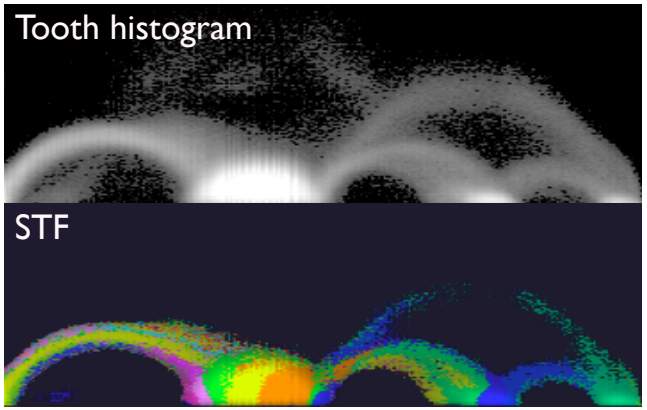
- Steps to yield right image:
  1) Define opacity mapping (gradient magnitude mode)
  2) Interactively adjust classification to have n=12 classes using a slider
  3) Select leaves and trunk by clicking at the green and brown area in the STF
- Advantages: fast, almost automatic, reliable, works for nD

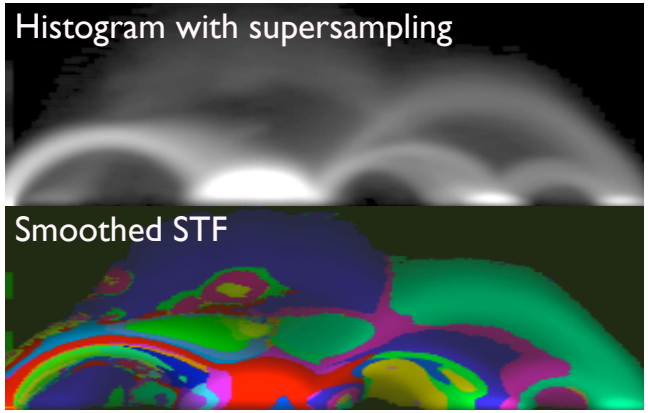


Noise Reduction

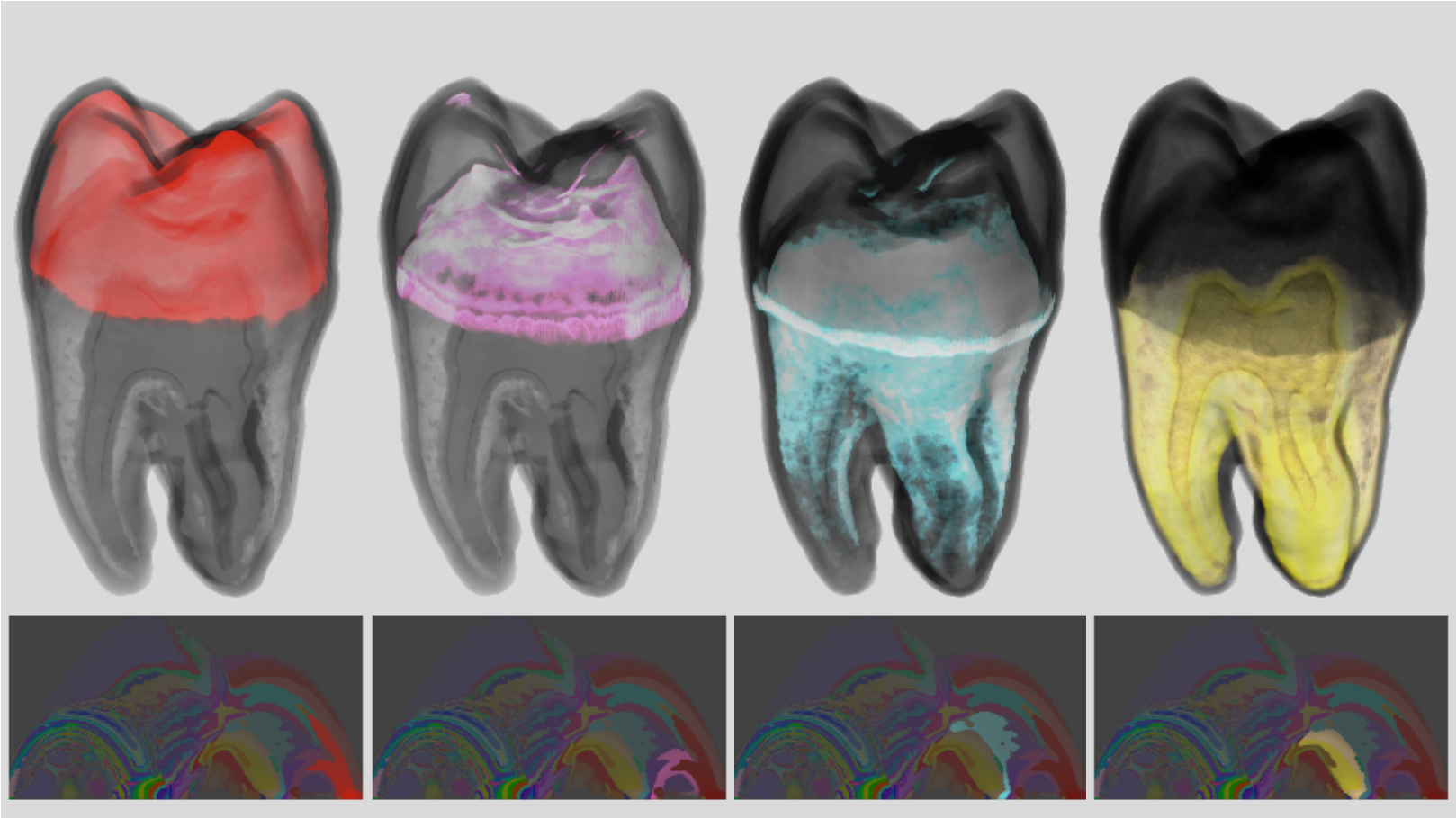
- 2D Histograms can be quite noisy
- If the voxel count of a point in the histogram is too low its voxel barycenter cannot be calculated precisely

- Solution: Increase voxel count by supersampling the volume



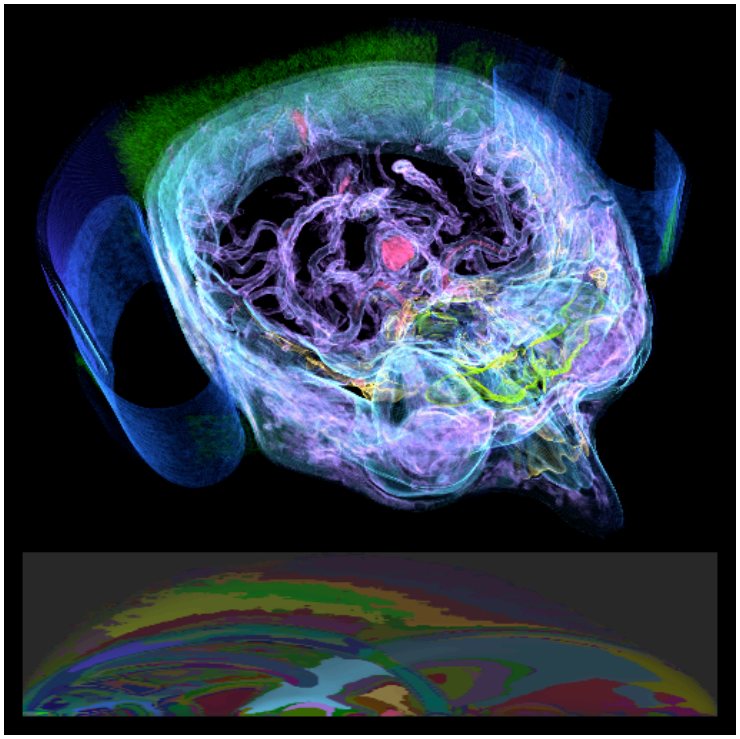


Tooth Example

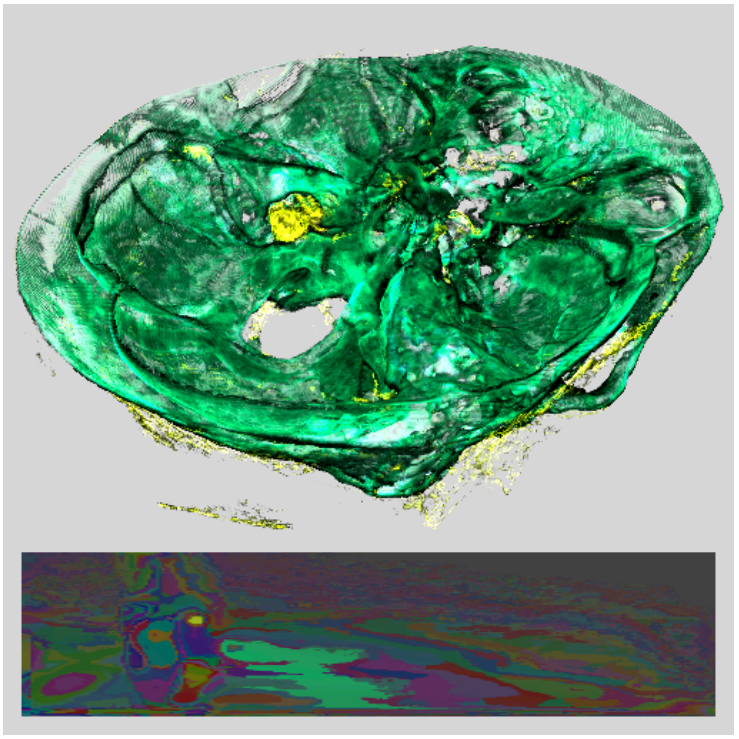


Selection of several substructures in the Tooth dataset

STF Usage



Aneurysm:
CTA / TF(s,g)



Tumor:
CT&MR / TF(s_{CT},s_{MR})

The End

THANK YOU!