Spatialized Transfer Functions

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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

\[ p = \int_{b}^{a} \text{optical props (t)} \, dt \]
TF Setup

- Simplest case is a 1D TF with zero emission and linear absorption which corresponds to X-Ray images.
- 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.

![2D Histogram Diagram](image)
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!