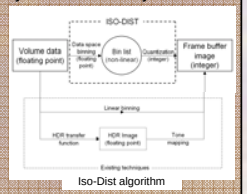
A User Interface for High Dynamic Range Transfer Function Design

Jürgen P. Schulze
California Institute for Telecommunications and Information Technology
University of California San Diego
jschulze@ucsd.edu

Amit Chourasia
San Diego Supercomputer Center
University of California San Diego
amit@sdsc.edu

Overview.
- Goal: development of user interface to simplify design of transfer functions based on iso-distribution (Iso-Dist) binning approach.
- Iso-Dist: volume data values evenly distributed into as many bins as graphics hardware distinguishes at rendering time (e.g., 256 for 8 bits per voxel).
- Each bin assigned color and opacity.
- Bins created by Iso-Dist are in data space: non-uniform, often lead to high color and opacity gradients in small range (see Figure B) and low gradients in other regions.
- Challenge: design a user interface which lets users work intuitively in non-linear data space and manipulate opacity and color easily.

User Interface.
- Transfer functions specified with widgets, similar to [1].
- One-dimensional transfer functions.
- Horizontal axis: data values in linear scale.
- Vertical axis: opacity in logarithmic scale.



Iso-Dist algorithm

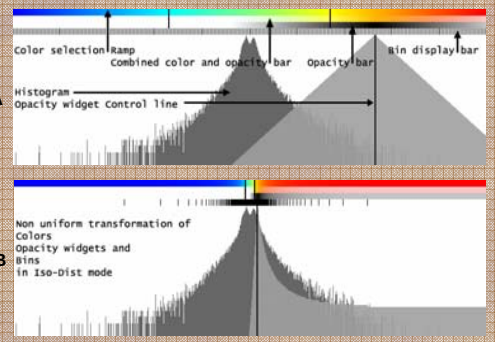
Bins.
- Bin boundaries indicated with black lines (see Figure B).
- Shows non-uniformness and denseness of transfer function.

Color Mapping.
- Color map displayed as color ramp at top of transfer function window (see Figures A and B).
- Below color ramp: color bar showing colors combined with opacity.
- In Iso-Dist mode: color map compressed in areas of high bin density, stretched where bins are wider (see Figures A and B).
- User can click on color control points, depicted as black lines, to change position or color.

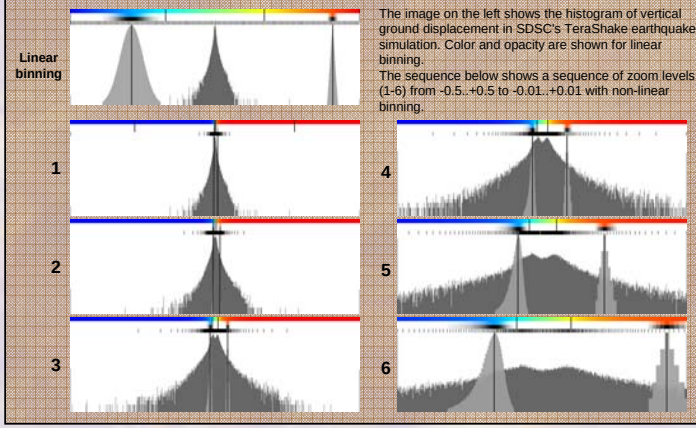
Opacity Mapping.
- Opacity function is composed of opacity widgets.
- Three opacity widgets to choose from: pyramid, Gaussian, control point based.
- Third bar on the transfer function graph is grayscale representation of opacity mapping.
- In Iso-Dist mode, opacity function is warped into non-uniform data space, just like color function.
- Opacity widgets can be modified in linear and Iso-Dist mode as needed.

Interaction.
- Transfer function over linear data axis (as opposed to [2]).
- Reason: users are used to see their data on a linear axis and use the histogram for orientation.
- Displaying data non-linearly flattens histogram (by design) -> useless for orientation.
- To allow fast transition between levels of detail: editor zooms in/out of data set with mouse wheel.
- Pressing mouse wheel down and moving the mouse left/right pans transfer function horizontally.
- Min/max values of displayed range can be numerically entered with keyboard.
- Additional button sets (resets) min/max to transfer function range.

Transfer function design is a critical task in volume visualization. Non-automated methods typically provide a user interface (UI) to accomplish this task. The UI is particularly important in real-time visualization when users continually change the transfer function to converge to a desired result. We present a graphical UI which integrates an editor for traditional transfer functions using linear color and opacity mappings, with novel, non-linear mapping methods used with high dynamic range data sets as used in [3]. Our UI has been designed for one-dimensional transfer functions. We chose to display the data space linearly so as to allow users to see it as they are used to, but add interaction methods like zoom and pan to move rapidly between different levels of detail.

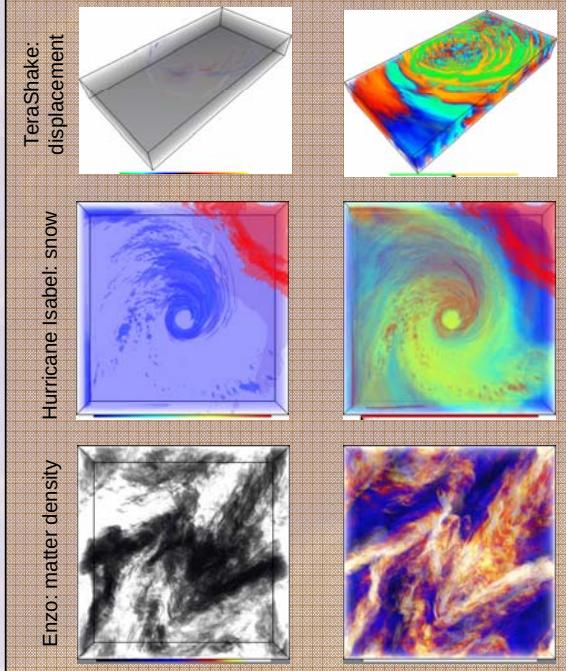


A pyramid opacity widget and color in uniform (A) and non-uniform Iso-Dist (B) mode. Data space is linear in both cases, but the color and opacity transfer functions are transformed into non-linear bin space.



The image on the left shows the histogram of vertical ground displacement in SDSC's TeraShake earthquake simulation. Color and opacity are shown for linear binning.
The sequence below shows a sequence of zoom levels (1-6) from -0.5..+0.5 to -0.01..+0.01 with non-linear binning.

Results.



Future Work.
- Add new opacity widget for freehand sketching of opacity function: give user more control of opacity function in non-linear binning mode.

[1] KNISS, J., KINDLMANN, G., AND HANSEN, C. 2001. *Interactive Volume Rendering Using Multi-Dimensional Transfer Functions and Direct Manipulation Widgets*. IEEE Visualization '01 Proceedings, pp. 255–262.

[2] POTTS, S., AND MOELLER, T. 2004. *Transfer Functions on a Logarithmic Scale for Volume Rendering*. Proceedings of Graphics Interface '04.

[3] YUAN, X., NGUYEN, M., CHEN, B., AND PORTER, D. 2005. *High Dynamic Range Volume Visualization*. IEEE Visualization '05 Proceedings, pp. 327–334.

SDSC SAN DIEGO SUPERCOMPUTER CENTER