A User Interface for High Dynamic Range Transfer Function Design

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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 [Yuan et al. 2005]. 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.

Introduction. We present a user interface developed to simplify the design of transfer functions based on an iso-distribution (Iso-Dist) binning approach. In Iso-Dist, the actual volume data values are evenly distributed into as many bins as the graphics hardware distinguishes at rendering time (e.g., 256 for 8 bits per voxel). Each bin is assigned a color and an opacity. The bins created by the Iso-Dist method are in data space so they are non-uniform and often lead to high color and opacity gradients in a small range (see Figure 1 b) and low gradients in other regions. The challenge is to design a user interface which lets users work intuitively in non-linear data space and manipulate opacity and color easily.

User Interface. Our UI transfer functions are specified with widgets, similar to those in [Kniss et al. 2001]. However, we use one-dimensional transfer functions and display opacity along the vertical axis in logarithmic scale for finer control at low opacities, the horizontal axis represents data values in linear scale.

Bins. We indicate the bin boundaries of the Iso-Dist algorithm with black lines (see Figure 1 b) to show the non-uniformness and denseness of the transfer function.

Color Mapping. The color map is displayed as a color ramp at the top of the transfer function window (see Figure 1). Below the color ramp is another color bar which shows colors combined with opacity to depict the actual transfer function. When in Iso-Dist mode, the color map is being compressed in areas of high bin density, and stretched out where the bins are wider. Figures 1 a) and b) demonstrate this difference. The user can click on color control points, depicted as black lines, to move them or change their color.

Opacity Mapping. The opacity function is composed of opacity widgets. There are three opacity widgets to choose from which can be combined to create the desired opacity functions: a pyramid, a Gaussian, and a custom, control point based widget. The third bar on the transfer function graph is a grayscale representation of the opacity mapping. When in Iso-Dist mode, the opacity function is warped into non-uniform data space, just like the color function. The opacity widgets can be modified in both linear and Iso-Dist mode as needed.

Interaction. As opposed to [Potts and Moeller 2004], we display the transfer function over a linear data axis which we found to be more intuitive to read and comprehend than a logarithmic axis. The main reason for this is that users are used to see their data on a linear axis and use the histogram for orientation. Displaying the data non-linearly so that the data bins are uniformly spaced flattens the histogram (by design) and, thus, makes it useless for orientation. In order to allow a fast transition between multiple levels of detail, the editor zooms in or out of the data set with the mouse wheel. Pressing and holding the mouse wheel down and moving the mouse toward left or right pans the transfer function graph horizontally. The minimum and maximum values of the displayed range can also be numerically entered using the keyboard. An additional button sets (resets) the minimum and maximum values to those selected as minimum and maximum for the transfer function range.

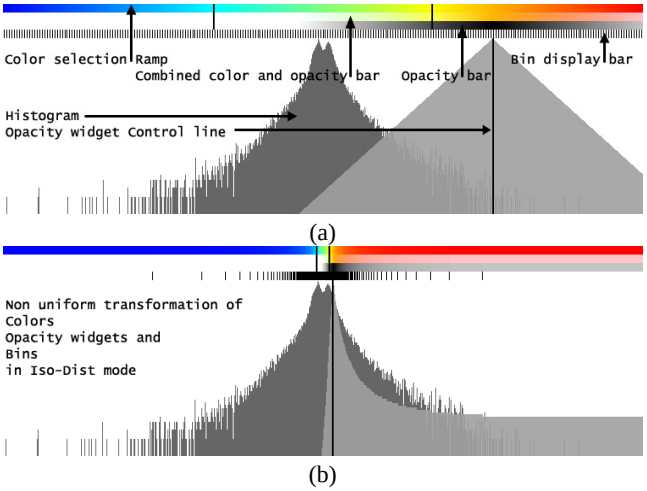

Figure 1: A pyramid opacity widget and color in uniform (a) and non-uniform Iso-Dist(b) mode. Data space is linear in both cases, but the color and opacity transfer functions are transformed into non-linear bin space.

Histogram. We find it important that the data space is always displayed linearly. This ensures that the histogram never gets distorted when using the Iso-Dist algorithm.

Future Work. In the future, we want to add a new opacity widget allowing freehand sketching of the opacity function to give the user more control of the the opacity function in non-linear binning mode.

References

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