Using data value as the only measure for controlling the assignment of color and opacity may limit the effectiveness of classifying features in the data. Incorporating other data measures into the transfer function, such as gradient magnitude, allows for finer control and more sophisticated visualization (Kindlmann and Durkin 1998, Kindlmann 1999). For example, see Figure 39-7 for an illustration of the difference between using one- and two-dimensional transfer functions based on the data value and the gradient magnitude.

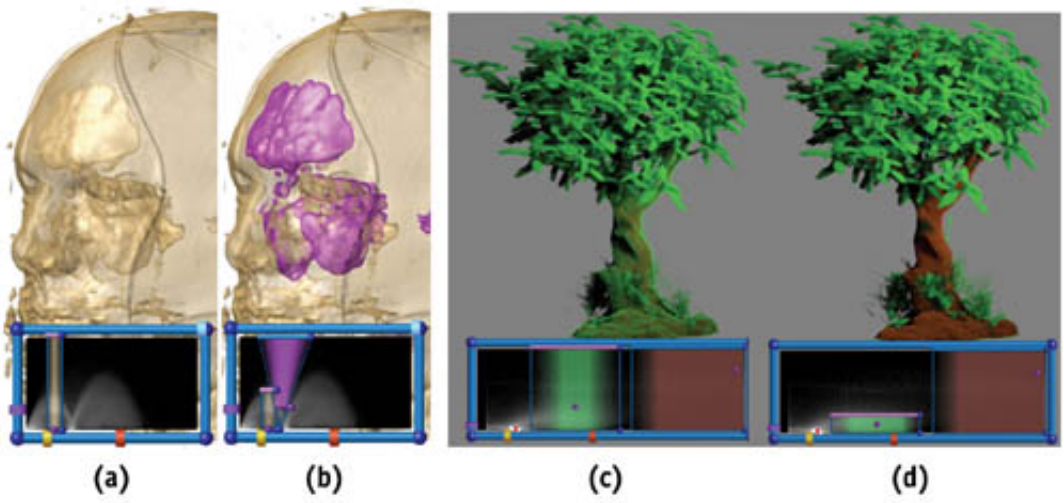

Figure 39-7 The Difference Between 1D and 2D Transfer Functions

Transfer function design is a difficult iterative procedure that requires significant insight into the underlying data set. Some information is provided by the histogram of data values, indicating which ranges of values should be emphasized. The user interface is an important component of the interactive design procedure. Typically, the interface consists of a 1D curve editor for specifying transfer functions via a set of control points. Another approach is to use direct manipulation widgets for painting directly into the transfer function texture (Kniss et al. 2002a). The lower portions of the images in Figure 39-7 illustrate the latter technique. The widgets provide a view of the joint distribution of data values, represented by the horizontal axis, and gradient magnitudes, represented by the vertical axis. Arches within the value and gradient magnitude distribution indicate the presence of material boundaries. A set of brushes is provided for painting into the 2D transfer function dependent texture, which assigns the resulting color and opacity to voxels with the corresponding ranges of data values and gradient magnitudes.

The assigned opacity also depends on the sampling rate. For example, when using fewer slices, the opacity has to be scaled up, so that the overall intensity of the image remains the same. Equation 3 is used for correcting the transfer function opacity whenever the