Chapter XI
Multi-Dimensional Transfer Functions Design

Hai Lin
Zhejiang University, China

ABSTRACT

Transfer function design is one of the most important procedures in volume rendering. Transfer function maps, which is a function mapping relationship, data values to display attributes, such as color and opacity. This chapter introduces region growing- based multi-dimensional transfer function design method, which can improve the effect of the multi-dimensional transfer function design, and help the users save the time used in the interactive design and decrease the difficult. In order to use the spatial information as independent variable, we combine spatial information to generate multi-dimensional transfer function. This chapter discusses the GPU-based transfer function lookup method and illumination parameter setting problems. In the last part of this chapter, we discuss the data layout of large scale volume data set and its volume rendering methods.

INTRODUCTION

Direct volume rendering is an effective method for data visualization. Transfer function design is one of the most important procedures in volume rendering. Transfer function maps, which is a function mapping relationship, data values to display attributes, such as color and opacity. According to the domain of the transfer function, there is one-dimensional transfer function and multi-dimensional transfer function. Transfer functions design has an important effect on the result of the volume rendering. Effective transfer function can distinguish visually different materials and different structures in an original data set, and remove the unimportant information while displaying the important structure in which people are interested. In the simplest type of transfer function, the domain of the transfer function is 1D, representing a scalar data value. Usually, one-dimensional transfer function can be designed through the gray histogram. One-dimensional transfer function can be designed easily, but it is difficult to identify the difference between materials. For example, CT data or MRT data may contain many materials and complex boundaries between different materials. When a scalar value relates to many materials, only using scalar data value is impossible to distinguish it.

Because of the limitation of the one-dimensional transfer function, people consider using other information to distinguish different structures and materials, and multi-dimensional transfer function is brought. While adding the gradient magnitude and other information, multi-dimensional transfer function can work better for distinguishing different materials. But multi-dimensional transfer function brings higher request for the interactive design. How to use the information of the original data set to design effective transfer function is our goal. This chapter introduces region growing-based multi-dimensional transfer function design method, which can improve the effect of the multi-dimensional transfer function design, and help the users save the time used in the interactive design and decrease the difficulty.

Transfer function design's other difficulty is that it does not use the spatial information as an independent variable, so it is difficult to classify the volume data, as the other region may contain the same scalar value. To solve this problem, this chapter combines spatial information to generate multi-dimensional transfer function.

In the last part of the chapter, we discuss the GPU-based transfer function lookup method and illumination parameter setting problems.

REGION GROWING-BASED METHOD OF AUTOMATICALLY GENERATED TRANSFER FUNCTION

The Multi-Dimensional Transfer Function

Multi-dimensional transfer function uses multi-information for classify volume data, not just only the scalar value. Using multi-information of the data can increase the opportunity of separating the attributes of materials and express the difference between different structures of the original dataset effectively. This data information can be regarded as coordinates of the transfer function domain (Kindlmann, 1998; Pfister, 2001).

We can use gradient magnitude as the second dimension of the transfer function while using the scalar value as the first dimension (Kindlmann, 2002). For scalar data, gradient can be retrieved from the first order derivative. As a vector, it denotes the largest variety direction. Normalized gradient are always used as normal in surface-based volume rendering. The magnitude of the gradient is a scalar value; it denotes the change ratio in the scalar value. In this chapter we use *f* representing the gradient magnitude of function *f*, and *f* is the function representing the scalar value of the data. We note:

$$f' = \| \nabla f \|$$

Using this value as a coordinate of the transfer function is useful. Within the same material, the scalar values are almost the same, so according to the attributes of the gradient, the magnitude of the gradient is small. On the boundaries of different materials, the scalar value is changing very quickly, and the magnitude of the gradient will be large. So we can use the gradient magnitude to distinguish the internal regions of the materials and the boundaries of different materials.

Because the data set is discrete, we need an approximate method to compute gradient.

For the internal points, we can use center derivative to compute the gradient of the point (i, j, k):

$$\nabla F_{i,j,k} = \begin{bmatrix} F_x(x_i, y_j, z_k) \\ F_y(x_i, y_j, z_k) \\ F_z(x_i, y_j, z_k) \end{bmatrix} = \begin{bmatrix} \dfrac{F_{i+1,j,k} - F_{i-1,j,k}}{2\nabla x} \\ \dfrac{F_{i,j+1,k} - F_{i,j-1,k}}{2\nabla y} \\ \dfrac{F_{i,j,k+1} - F_{i-1,j,k-1}}{2\nabla z} \end{bmatrix}$$

Related Content