Moment Based Transfer Function Design for Volume Rendering

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Abstract. Local data features play important roles in the transfer function design for volume rendering. By examining relationships among three eigenvalues of *inertia matrix*, a semi-automatic data-driven transfer function design method is presented in this paper. Local features detected by local block based moments, such as flat, round, elongated shapes are used to guide the design of transfer functions. Furthermore, the proposed method can objectively fulfill the function of the previous boundary based method and extend the domain of transfer function to include more data features. Practice experiments are conducted to render real medical data sets by using the proposed transfer function method.

1 Introduction

Direct volume rendering has gained great popularity as a powerful technique for the visualization of 3D volume data sets such as those obtained from computed tomography (CT), magnetic resonance imaging (MRI), computational fluid dynamics (CFD), and volumes which are generated by voxelizing geometric models in recent years.

Unlike surface based method, such as marching cubes[1] which draws geometric surfaces out from the volume data sets using threshold values determined by segmentation, in direct volume rendering[4][2][3][5][6], the transfer function is responsible for the classification of a data set. Its task is to assign optical properties such as color and opacity to values the data set consists of. During the rendering process, the sampled and/or reconstructed data values are passed through the transfer function to determine their contribution to the final image. So transfer functions are crucial to the quality of the final rendering images. Good transfer functions resulted informative renderings which reveal the essence and help people gain insight of the original data sets.

Unfortunately, interactive designing of a high performance transfer function which can produce an informative rendering has been proved difficult. First, in cases, little pri-knowledge makes it difficult to obtain information and gain understanding of the data set. Second, the same data value may belong to different structure or matter, in reverse, the same structure or matter may present the

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same data value due to noise. In another word, automatic segmentation and classification of arbitrary volume data is still difficult in science. Third, complexity of the volume rendering process results in the nonlinear relationship between the optical properties produced by the transfer function and the final rendering image. Trivial tune of transfer function may lead to tremendous change in the final rendering. At last, the time-consuming process of the volume rendering makes it more expensive to evaluation of the selected transfer function.

A new *data driven* transfer function design method which uses three eigenvalues of *inertia matrix* to measure local shape features is presented in this paper. The proposed method extends the domain of transfer function, and can be used efficiently to detect local flat, round, and elongated shape features.

2 Previous Work

The earliest and also the most generally used method to set a transfer function is *trial-and-error*, which is at the same time frustrating and time-consuming.

Much work has been done by the research society in recent years. There exist two distinguish categories in the previous research on transfer function design. One is termed *image-driven* in which the rendering results is exploited to guide the design of transfer function, and the other is *data-driven* in which the user mainly concentrates on exploration of the inherent characteristics of the data sets.

As for image-driven methods, He et al. [7] describes the search of good transfer functions as a parameter optimization problem. One of common genetic algorithms—stochastic search is used to achieve global optimization. The method succeeds in generating good renderings,and frees the user from having to edit the transfer function manually. Marks et al. [15] treat the design of transfer functions as a "parameter tweaking" problem. In this paper, "design galleries" interfaces are implemented to present the user with broad selection, automatically generated and organized of perceptually different graphics or animations. Fang et al. [16] presents an image-based transfer function model based on three dimensional (3D) image processing operations. König and Gröller [8] organize the rendered thumbnails efficiently to guide the transfer function process based on volume hardware.

As for the data-driven methods, Bajaj et al. [9] describe a tool for assisting the user in selecting isovalues for effective isosurface volume visualizations of unstructured triangular meshes for isosurface rendering. Fujishiro et al. [17] use a "Hyper Reed graph" to depict the isosurface topology at any given isovalue, as well as the isovalues corresponding to critical points where the topology changes. Given some assumptions about what topological characteristics signify important isosurfaces, this information can be used as guidance to set isovalues and transfer functions. Or, if isosurfaces at the critical values are assumed to be important, setting isovalues and transfer functions can be largely automated. Kindlmann et al . [11] [12] demonstrates an innovate semi-automatic transfer function design method based on the analysis of a three- dimensional histogram