

FOCAL REGION-BASED VOLUME RENDERING

JIANLONG ZHOU AND KLAUS D. TOENNIES

Institute for Simulation and Graphics, University of Magdeburg, GERMANY

E-mail: {zhou, klaus}@isg.cs.uni-magdeburg.de

In this paper, a new approach named focal region-based volume rendering for visualizing internal structures of volumetric data is presented. This approach presents volumetric information through integrating context information as the structure analysis of the data set with a lens-like focal region rendering to show more detailed information. The approach provides a powerful framework for producing detailed information from volumetric data.

1 Introduction

Volume visualization has been widely used as a method to explore information from volumetric data sets in the area of medical imaging, meteorology, and other fields. During the last decade the developments in image modalities, such as Multislice-Spiral CT in medical imaging, have led to create higher resolution and larger volumetric data sets. However, in these data sets the structure of interest (tumours, lesions, arterial structures, etc.) occupies a percentage of the voxels that is often below 10% of all voxels. In practical applications, the analysis of such structures needs efficiently extraction of the volume of interest while preserving data structures around it to provide context information.

In this paper, we propose a rendering approach that integrates context information as the structure analysis of the data set with a lens-like focal region rendering to show more detailed information. The volume data is divided into two parts by a geometry primitive (e.g. sphere, cube): context region and focal region. In the context region, the dominant features are extracted and rendered prominently while in the focal region, the detailed information of volume data is presented.

This feature-based approach contains three main components to meet three types of requirements in order to provide more detailed information of the volumetric data set:

- A feature extraction model using 3D image processing techniques to explore the structure of object to provide context information.
- An efficient ray-bounded volume ray casting rendering to provide the detailed information of the volume of interest in the focal region.
- Tools for interactive specification of focal regions and modulation of transfer functions which are used to determine

what to be shown in the focal region.

2 Related Work

Recent research in volume rendering tends to combine different rendering methods together to explore more information from volume data [1, 2]. An ideal method of visualizing 3D volume data should include the ability to interactively remove obscuring objects and to obtain relevant information about selected objects or groups of objects. Our approach uses the idea to create a rendering pipeline: focal region for detailed information and context for structure of the data. This approach extends the traditional volume rendering methods and can create partial volume rendering.

3 Context Region Rendering

The context is mainly used to show structure of the data. In the context region, our interest is object boundaries. The object boundaries and edges often carry most of the relevant information. This can largely avoid spatial overlapping. In the context, the dominant features are extracted and rendered prominently.

3.1 Feature Extraction

The goal of feature extraction is to find interesting features in the data more or less automatically and to extract the features and calculate quantitative attributes describing the characteristics of that feature. Most of the volume features are gradient and viewing direction dependent.

Our feature extraction process is as follows: firstly the volume gradient and gradient magnitude are computed using 3D image processing method, then it is checked at every sample position whether the gradient magnitude is a local maximum. This is obtained through detecting the largest gradient magnitude along the gradient direction. A local maximum gradient magnitude is found when the gradient magnitude is strictly larger or equal than the neighbor in the opposite direction, and vice versa. We create a binary mask volume with mask values set to one if the corresponding voxel has a local gradient length maximum. This mask volume contains the boundary information of the original volume data. We use this mask volume to control the final original volume compositing process.

3.2 Rendering Pipeline

From the feature extraction process, we obtain an additional volume data set of equal resolution in which the volume feature information is coded. The boundary information has to be integrated into the rendering

pipeline. In direct volume rendering algorithms the pixel intensity on the viewing plane at a certain position is computed by evaluating the well known volume rendering integral

$$I(t_0, t_1) = \int_{t_0}^{t_1} q(t) e^{-\int_{t_0}^t \sigma(s) ds} dt \quad (1)$$

along each viewing ray. It sums up the contributions of the volume emission $q(t)$ along the ray.

Recall that we have encoded the local maximum information of the gradient magnitude into a mask volume which contains boundary information of the volumetric data set. Now we use this mask volume in the compositing step. The final context region is obtained through compositing the original volume using ray casting method. Equation (1) is evaluated on the original data set only if the ray meets a voxel position where the corresponding position in mask volume is 1. Otherwise the segments opacity is set to zero.

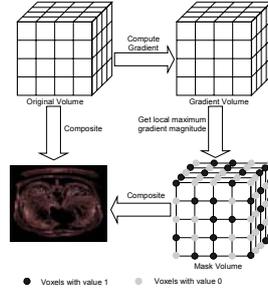


Figure 1. Context region rendering pipeline.

The main advantage of this approach is that it can provide more structure information than standard ray casting method.

4 Focal Region Rendering

The focal region is our main area of interest. It should provide users with more detailed information on the volumetric data set.

For efficient rendering and providing more information, we present a method of volume ray bounding during ray casting in our focal region rendering. The rays are bounded by a user defined geometric shape (e.g. sphere, ellipsoid, cube) according to the volume of interest. The volumetric features can also be enhanced in this way and the rendering can be accelerated by avoiding unnecessary volume traversals. We have presented this method in our previous research [3].

5 Results and Discussion

This section describes how our approach is used in medical data sets (CT data set of liver) to extract structures of the objects and focus on the

specific objects of interest to show detailed information at the same time. The method was implemented on an AMD Athlon /1.0GHz PC with 512MB memory using C++. The size of the CT data set of the liver is $256 \times 256 \times 60$. Because of the gradient computation in the context region, it takes about 40 seconds to create the context region using boundary controlled ray casting. After the context region is created, the focal region can be rendered. The rendering time depends on the size of the focal region. For spherical focal regions of diameter 20 to 40 pixels rendering could be carried out at 0.5 to 1 frame per second.

Figure 2 shows the results of focal region-based volume rendering using boundary mask volume controlled ray casting to composite the original volume to represent context information. At the same time, the specific vessels are presented in the focal region. In the context region, the important features like contours of the liver and vessel structures outside of the liver are depicted.

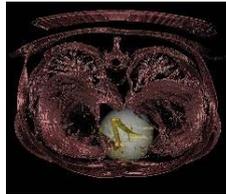


Figure 2. Using boundary mask volume controlled ray casting to compositing the original volume to represent the context information and the focal region is also displayed.

6 Conclusions

We introduced the concept of focal region-based volume rendering for providing context information for structure analysis of the data set with a lens-like focal region rendering to show more detailed information about volumetric data. The combination of context information and a focal region rendition produces an intuitive tool for exploring volume data. We expect that in the focal region-based approach the feature extraction techniques will be improved and extended.

References

1. H. Hauser, L. Mroz, G. I. Bischi and M. E. Groeller, Two-Level Volume Rendering. *IEEE Transactions on Visualization and Computer Graphics*, 7(3): 242-252, 2001.
2. P. Rheingans and D. Ebert, Volume Illustration: Nonphotorealistic Rendering of Volume Models. *IEEE Transactions on Visualization and Computer Graphics*, 7(3): 253-264, 2001.
3. J. Zhou, M. Hinz and K. D. Toennies, Hybrid Focal Region-based Volume Rendering of Medical Data. In *Proceedings of Bildverarbeitung für die Medizin*, pages 113-116, Leipzig, March 2002.