Parallel Visualization of Large Medical Datasets Based on Computer Cluster

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Abstract *– Scientific visualization of medical images, which is of great value in medical research and clinic diagnosis, has been a focal field in recent years. After brief description of basic concepts, the essence and techniques of parallel visualization of large medical datasets are discussed. The Maximum Intensity Projection （MIP） algorithm is realized in parallel using common PC cluster and programming in IDL 6.0. Experimental results demonstrate that this parallel technology can provide promising and real-time results, which play great role in clinic diagnostic. Finally, discussions and some practical observation on the direction of further research are given as a conclusion.*

Keywords *– scientific visualization, parallel visualization, maximum intensitypProjection (MIP), medical images*

I. INTRODUCTION

As the gradual developments and wide applications of modern medical apparatuses, all kinds of medical images have been playing critical role in clinic diagnostic and medical research. Up to date, physicians are still conditioned to discover and observe focus's information through multiple 2D slices of CT or MRI. This process is a procedure of qualitative analysis of medical images, with noises brought about unavoidably. In recent years, scientific visualization of medical images has been a focal field in that it can make up the deficiencies of medical apparatuses, provide physicians with 3D medical images to analyze complex anatomies and their relationship by means of qualitative and quantitative methods, increase the speed and accuracy of diagnoses. In a word, 3D visualization plays a great role in clinic diagnostic, surgery planning and simulation, education training and so on.

IDL (Interactive Data Language),a complete computing environment for interactive analysis and visualization of data, is a significant product by Research Systems Inc. The characteristics of IDL include followings [1], the details referred to [2].

1) IDL integrates an array-oriented language with mathematical analysis and graphical display modules.
2) IDL operators and functions work on array, which simplifies interactive analysis and reduces programming times.
3) IDL provides many numerical and statistical analysis routines for custom data format, common image standards and scientific data.
4) IDL widgets can be used to create multi-platform graphical user interfaces.

Medical image dataset is so massive in size that it is often overload for common PC and even for graph workstation with multiple CPUs. It is an efficient way to visualize and simulate large medical datasets in parallel on high performance clusters of super-computers or multiple-node clusters of PCs. Therefore, the article is organized as following: firstly parallel visualization and Maximum Intensity Projection algorithm are introduced respectively; secondly experimental results are provided; finally some practical observation on the direction of further research are discussed.

II. PARALLEL VISUALIZATION

"Distributed Processing" is an important strategy in parallel visualization. It can be classified into Data Space Subdivision (DSS) methods and Image Space Subdivision (ISS) methods. The former means to divide volume datasets into several portions, which can be processed by different processors. The latter means to divide whole image into several portions, also processed by different processors [3].

The hardware configuration of system is similar with master-slave computer system (Fig.1). The master controls tasks distribution among all slaves. Then each slave collects, initializes, and computes sub-image, respectively. Finally, all the results of slaves are transferred to the master to be stitched into the final image.

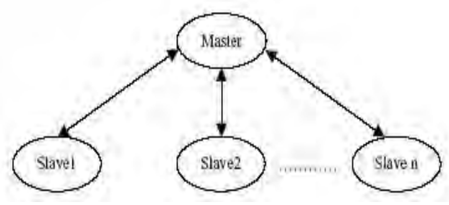

Fig.1 Master-Slave Computer System

The software flow chart of the whole system is shown in Fig.2, which can be divided into three steps: dataset subdivision, sub-datasets visualization and sub-images stitching. For each slave, its software flow chart includes: data requisition, data pre-processing, mapping, rendering and display, referred to Fig.3 [4].

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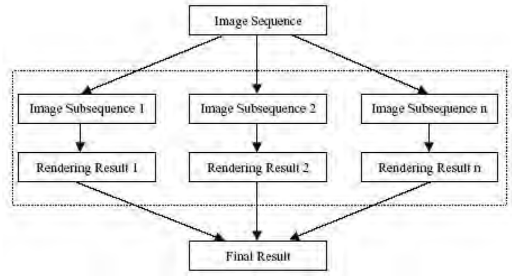


Fig.2 Software Flow Chart of the Whole System

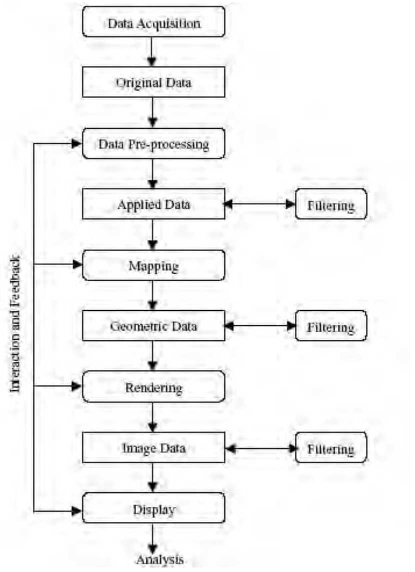


Fig.3 Software Flow Chart of Each Slave

III. MIP ALGORITHM

According to the data description method, 3D reconstruction techniques from medical images are classified into two categories: surface reconstruction and volume reconstruction. In addition, those algorithms merged the characteristics of these two, are of the third category - hybrid reconstruction.

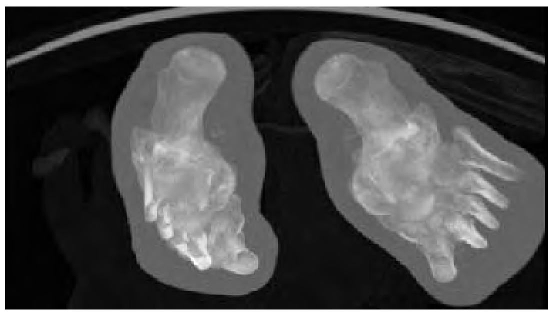
Volume reconstruction uses all of the information contained in image dataset, leading to no unwanted loss of information theoretically. By assigning a specific color and opacity value to every attenuation or signal intensity value of CT or MRI data, voxels can be grouped and selected to display [5]. The information from all of the voxels is collected along the viewing way, while the information from every voxel is integrated into the resulting image. Meaningful and valid 3D representations of structures are possible, depending on the selected opacity value [5]. Up to date, there are various volume reconstruction algorithms, such as raycasting approach, footprint approach, shear-warp approach, frequency domain volume rendering approach, wavelet-based volume rendering approach and so on.

Maximum Intensity Projection (MIP) is a special case of raycasting approach. In MIP, the intensity assigned to a pixel in the reconstruction results is simply the maximum scene intensity encountered along the projection line. This algorithm is most effective when the objects of interests are the brightest in the scene and have a simple 3D morphology and a minimal gradation of intensity values. MIP is commonly used in contrast material enhanced CT angiogram and MR angiogram. Its main advantages are that it requires no segmentation and is robust to noises [6~7].

IV. EXPERIMENTAL RESULTS

Parallel visualization of medical images is programmed in IDL 6.0 in common PC cluster with 2.93G CPU, 256M memories. First, three large datasets are applied to validate the program. The MIP results of renal MRA images (data size $448\times72\times576$, voxel size $0.63\times1.40\times0.63$) and abdominal CTA images (data size $512\times512\times288$, voxel size $0.74\times0.74\times1.50$) are shown in Fig.4. The MIP results of foot CTA images (data size $512\times512\times250$, voxel size $0.58\times0.58\times1.00$) are shown in Fig.5 from axial, coronal and sagittal direction. Finally, an extreme large dataset is used. As far as abdomen and lower extremities CTA images (data size $512\times512\times1624$, voxel size $0.96\times0.96\times0.8$), it is divided into four $512\times512\times320$ and one $512\times512\times344$ sub-images to be rendered by each slave, then the whole image stitched by master shown in Fig.6.

Fig.4 MIP Results of Renal MRA Images and Abdominal CTA Images



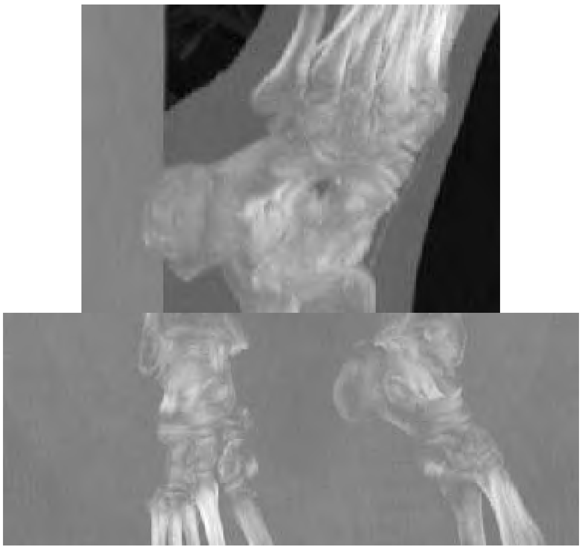


Fig.5 MIP Results of Foot CTA Images

Fig. 6 MIP Result of Abdomen and Lower Extremities CTA Images

From the experimental results shown above, it is concluded that the MIP algorithm reflect intensity information and vessels, bones can be displayed clearly. However, this method cannot reflect depth information and cannot distinguish situational relationship between these structures.

V. DISCUSSION AND CONCLUSION

The strategy and methodology to realize parallel visualization of medical images using common PC cluster and programming in IDL 6.0 environment are proposed in this article. The visualization results and computing performance demonstrate that this program can provide promising and real-time solutions of extreme large medical datasets.

However, our system is still a research prototype, and future research include:

1) improve original MIP algorithm, adding depth information to reflect situational relationship of structures.

2) segment, extract and measure organs, tissues and vessels in 3D on the basis of rendering result.

3) examine and utilize spare computers in intranet of the hospital in order to improve efficiency and decrease expenses.

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