Zoological Studies 34, Supplement I (1995)

Zoological Studies

The Visualization System for Cross Sectional Images

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Recently, the scientific visualization techniques have been widely used in medicine, biology, geography, and many other scientific and technical researches. The scientific visualization exploits sophisticated computer graphics and data processing techniques, such as 3D reconstruction of histological, optical, and tomographical sections, to gain insight and understanding of complex problems characterized by large data sets. In the last couple years, many scientific visualization systems have been developed, such as AVS (Upson et al. 1989), apE (Dyer 1990), and IRIS Explorer (IRIS 1991), and DISCOVER (Chen et al. 1994).

In this paper, we describe a distributed computing system for scientific visualization applications, called "DISCOVER" (a Distributed Interactive Scientific Computing and Visualization Envi Ronment) (Chen et al. 1994). Currently, the system is a medical application framework targeted at physicians in hospitals for clinical applications. The system allows users to interactively display and manipulate the 2D and 3D medical objects, visualize the results, take control of the system computation, and drive the analysis and discovery processes. The system can also be used for the visualization of other scientific data: either numerically computed data, such as the pressure distribution within a fluid reservoir, or empirically measured data, such as tomography radiation measurements or microscopy images.

Our system consists of a virtual host, which consists of one or more personal computers, and one or more workstations, which are the computation servers. Each window in the virtual host is a client of the computation servers. When a command is issued by the user from any window in a host, it is sent to a global command queue and waits for being broadcasted to all the computation servers. After the computation is done, the results will be sent back to the client. In other words, the command queue can be thought of as a single virtual client of the computation servers in the whole system.

In our system, we use MS-windows 3.1 as the underlying window system for the user interface (Fig. 1). Images created by various medical modalities such as CT and MRI are converted into a specific volume data format that is suitable for further processing. The data structure of the volume data, called a quadtree-segment structure, is based on the combination of a quadtree and a run length encoding scheme (Chen et al. 1989). The run length encoding is used along the X direction and a quadtree data structure is used on the Y and Z dimensions to some level. On the bottom level (the leaf of the quadtree), each node is a 16X16 square in size. In other words, an object data consists of a quadtree and a lot of 16X16 node data structures, called boxes, that are pointed to by the leaf node of the quadtree.

There are four different types of windows in the system; a global command window, 2D image windows, 3D image windows, and album windows (Fig. 1). The global command window is used to display and issue the global commands to other three kinds of windows. The 2D/3D image windows are used to display 2D/3D images respectively. The album windows are used to simulate the traditional film-based medical images and the viewing boxes used by the physicians. The medical images, such as CT or MRI images, are displayed in the album window in a row by row, column by column fashion. Images can be moved around inside the album window for comparison just like the photos in an album. The images of interest in the album can be brought to the 2D image windows for more advanced processing.

For the 2D image window, there are three classes

Fig. 1. The graphical user interface of the DISCOVER system. The global command window is on the upper-right corner. The album window is on the lower right corner. The 2D image and 3D image windows under "NCKU DISCOVER" are activated (see the green boxes) and are thresholded simultaneously.

Fig. 2. Some 3D image processing techniques provided by the DISCOVER system. (a) The manipulation with a specified depth (z = 145). (b) The volume surface rendering after the manipulation (a). (c) The volume rendering of the object (b). (d) Another manipulation with a specified depth (z = 190). (e) The volume surface rendering after the manipulation (d). (f) The volume rendering of the object (e).

of tools for image processing: (1). Image manipulation tools, such as zooming and panning, contrast and windowing. (2). Image processing tools, such as high-pass and low-pass filters, histogram equalization, detecting connected components, image combinations, and display of histogram. (3). Image analysis tools, such as density, distance, and angle measurements, coordinates, and drawing region of interest.

For the 3D image windows, there are many 3D visualization and manipulation tools available. The visualization techniques includes surface rendering, volume rendering and volume-surface rendering (Chen et al. 1994) (Fig. 2). The surface rendering method we use is a front-to-back rendering method (Reynolds et al. 1987, Chen et al. 1989). In this method, line segments are used to represent both object and image generated. This method is a fast method to render a complex voxel-based object, such as a medical object. In many clinical applications, there is a need to visualize the spatial relationship between the outer shape of an object and its internal detailed structures. For this purpose, a visualization technique called volume-surface rendering is provided to let user visualize the external and internal structures of medical objects simultaneously. The manipulation processes includes 3D thresholding, cutting the object with a contour specified on the screen, connected component detection, and logical operations such as AND, OR, or XOR, to create new objects.

The DISCOVER system, as it stands today, is in practical use in the Hospital of National Cheng-Kung University in Taiwan for real clinical applications. Physicians can use their desktop personal computers to run the DISCOVER. Due to the fact that the DISCOVER system can process any kind of 2D sectional images and reconstruct them into 3D, we hope that the DISCOVER system can be applied in more research areas in addition to medicine very soon, such as microscopy in neurobiology or cell biology.

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