A Tele collaborative Surgery Framework for 3D Heart Model

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Abstract: - Tele-collaborative projects have become more popular in recent years due to shared professional knowledge especially in biomedical fields. This research will offer great benefits not only for the surgeon but also researchers of synchronous distributed system. The goal of this study is to investigate the architecture of a network which allows collaborative surgery. At the master station, the surgeon will be able to view the manipulation carried out by the other surgeons remotely, including the master which resides in his computer. To optimize the time varying and visualization process, we have chosen an approach that process on three dimensional (3D) point volume data by using Visualization Toolkit (VTK) with parallel processing. In this paper, we presented an architecture which enables 3D heart model visualization tasks to be performed efficiently in collaboration environment.

Key-words: - Tele-collaboration surgery, VTK parallelism, 3D Heart Model.

1.0 Introduction

The term "Tele-collaboration" has been widely used in recent years. The general aim of collaborative project is to provide WYSIWIS (What You See Is What I See).[4] Tele-collaboration as practiced in the operating room uses telecommunications technology to connect surgeons and other medical professionals to another operating room and its personnel. Tele-collaboration enables remote consultation, evaluation, mentoring, monitoring and performance of surgical procedure. [6]

In this study we are using 3D fiber fluid heart model which is proposed by David M. McQueen and Charles S. Peskin. [10] The heart model consists of 4,000 fiber points representing 600,000 discrete points. The simulation is done using Immersed Boundary Method (IBM) and consists of 57,000 time steps. These heart models are used for further visualization, simulation, and understanding the structures and relationships that may exist among the data. However, these procedures are rarely performed by one individual but by a group of collaborators that normally are not residing at the same location. This will make collaboration difficult and costly. Not only that, 3D biomedical data are in a very large scale and time varying. Unfortunately, 3D heart visualization still not yet performed in a Tele-collaborative environment currently. Therefore, we would like to perform a visualization tasks on 3D heart model in a Tele-collaborative environment. For example, a surgeon or a biomedical researcher can share results from the heart visualization with distant collaborators. Furthermore, all collaborators can also control and modify the parameters and also display the results. In this study, we would like to impose with a minimal system requirements where users can collaborate by using X-windows applications across network.

2.0 Related Work

There is a lot of Tele-collaboration projects have been studied and implemented. However, a lot of them are not study in 3D model especially heart data which implemented in a Tele-collaboration environments. One of the study, Tele-collaborative Data Exploration (TDE) [11], it is study on physically based data segmentation which is using snakes, multi-spectral statistical color image segmentation using 3D histograms, and volume-probing in a Tele-collaborative environment. While, Network Oriented Visualization in Clinical Environment (NOVICE) study on 2D and 3D clinical case in a web based environment. Advanced Visualization System (AVS) has concentrated its development work on 'fat' clients for visualization and data analysis on the client side using both their own AVS/Express visualization product and Microsoft's Active/X system for client development. Then, there is a Java based Tele-collaboration Groupware which is focused on the implementation of a whiteboard where a good Tele-teaching tool is discussed and using Java as the programming language. [4]

3.0 Construction of 3D Heart Model

To provide an efficient method of inputting data to the visualization cluster it was necessary to implement a new type of 3D data. Therefore we chosen a model of the heart which made up of over 4,000 fibers and over 600,000 points, which will be simulated using the Immersed Boundary method (IBM).This new data format will provides a simpler, more structured, and more portable way of handling 3D Heart Model data. The construction model is shown in Fig. 1.

4.0 Network Architecture

This system consists of several non hierarchical logical tiers which include *Management tier/Master node, Compute tier* and A*ccess tier/Access nodes.* The illustration of the architecture is shown in Figure 2. The management tier will provide a major cluster services such as job management while the Compute tier will provide the compute power to process the 3D points dataset. It will also supports the runtime for VTK applications which a large collection of visualization tools to analyze, slice, and render image, volume and geometric data. Clients need not to require very high end hardware. We expected to increase the performance of data processing fast centralized compute server architecture. In Figure 3, it shown a simple scenario of updates exchanged in a collaboration system. When user A made a modification on the client side, the updated data should be sent to other user B and C as well. Then, user B and C will updates their results.

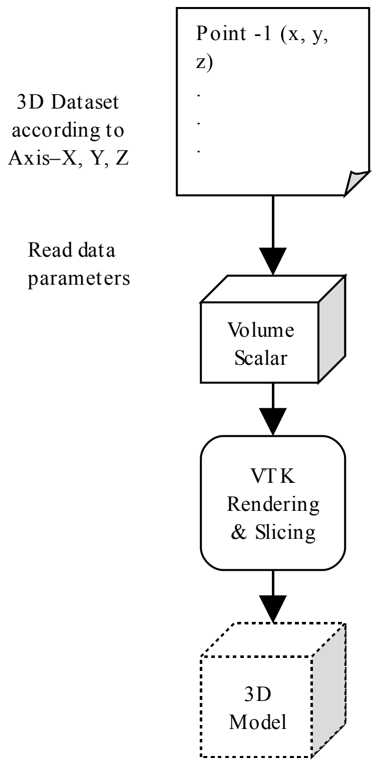

Fig.1: Construction of 3D Model

5.0 Visualization Software

In this research we are using Visualization Toolkit (VTK) to parse and display 3D

Heart Data. This is because VTK is an open source, portable, object-oriented system for 3D computer graphics [1]. It is implemented in C++, VTK also supports Tcl, Python, and Java language bindings, permitting complex applications, rapid application prototyping, and simple scripts. Although it is not providing any user interface, it can components, it can be integrated with widget set such as Tk and X/Motif.[1] It also consists of variety of built in visualization process which includes rendering, volume slicing, and parallelism. Other than that, it can step through various time steps of the integrated model solution in order to produce an animation. In Figure 4, it shown a simple visualization of a 3D heart model which performed by using VTK.

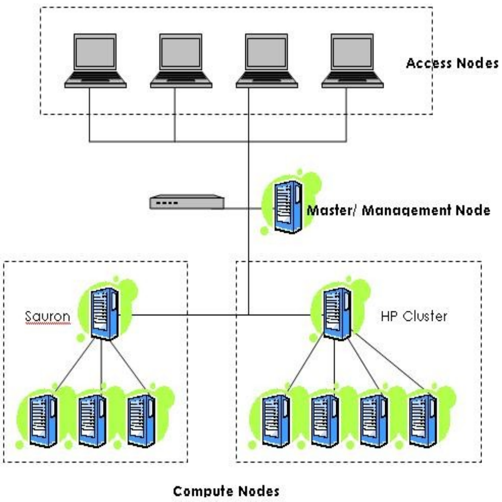

Fig.2: Simple Network Architecture

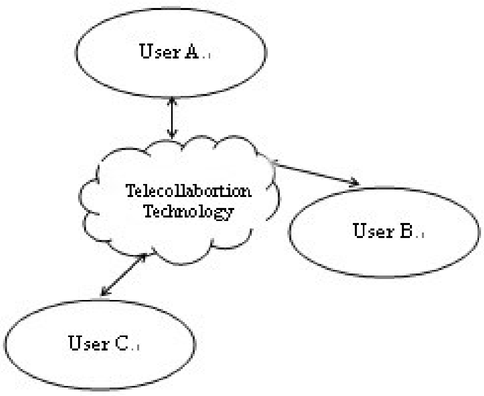

Fig.3: Update of data in Collaboration System

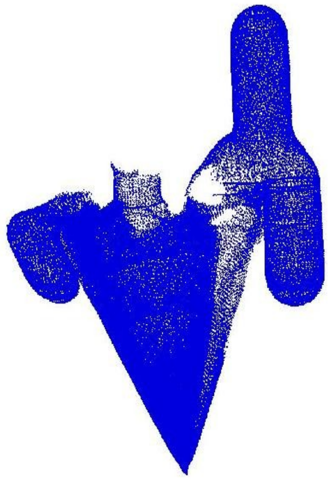

Fig.4: Example of Visualization of 3D heart model by using VTK

6.0 Graphic User Interface

The creation of 3D heart model visualization consists of several important functionalities:

- Loading and displaying the 3D data
- Rotating and Zooming
- Edition of the heart parameters: such as viscosity, pressure point, velocity of blood at certain point.
- Save as image
- Chat space for users to exchange information.
- Figure 5 shows a prototype graphic user interface (GUI) which is created by using Java Netbeans.

7.0 Conclusion

With the introduction of utilization the component in VTK, we have shown that VTK is a suitable framework for cluster-based application. To optimize the time varying and visualization process, we have chosen an approach that process on 3D point volume data by using Visualization Toolkit (VTK) with parallel processing. In future we would like to implement the 3D Heart Data by using different VTK rendering algorithm, and also other manipulation such as volume slicing. Other than that, a user friendly interface will be created. Finally, all

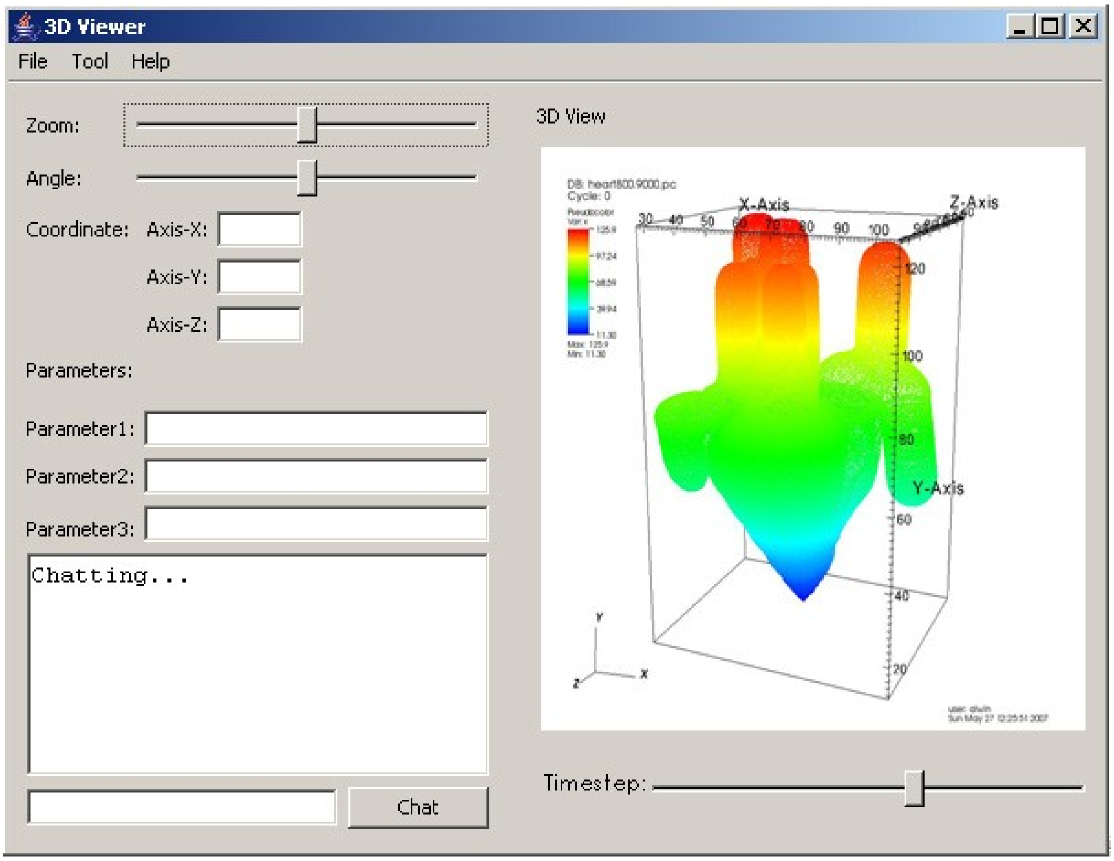

Fig. 5: Prototype GUI

processes should be performed in a Tele-collaboration environment.

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