DEVELOPMENT OF INTERACTIVE MODELING SYSTEM FOR THE COMPUTATIONAL BIOMECHANICS SIMULATION USING MEDICAL IMAGING DATA

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Abstract. *Computational mechanics has been recognized as a powerful tool for cardiovascular disease research, vascular surgery planning and medical device design. The accurate and efficient construction of anatomic models is a critical element in the application of these computational methods. We developed an interactive modeling system for the computational biomechanics simulation using medical imaging data such as MRI or CT. The novel aspect of this modeling system is that the operator can modify the model which is rendered over the reference volumetric images. Therefore efficient modeling can be done with help of the heuristic knowledge of the operator.*

Keywords. *Computational Biomechanics, CFD, Image Based Modeling, Medical Imaging Data, Volume Slicing.*

1 INTRODUCTION

Biomechanical simulation using realistic geometric models of blood vessels is needed for elucidation of the cause of various vascular diseases such as atheroarteriosclerosis and aneurysm, teatment planning and evaluation, and medical device design. Methods to construct realistic models automatically from medical imaging data were introduced. Medical imaging data in the real world contains various artifacts, which make it difficult to construct realistic models automatically. We developed a novel modeling system to construct geometric models from medical imaging data interactively with directly using the operator's anatomical knowledge and ability of space perception.

The novel aspect of this modeling system is that the operator can modify the model that is rendered over the reference volumetric images which can be acquired with medical imaging devices such as MRI or CT. Therefore the accurate and efficient modeling can be done with the help of the heuristic knowledge of the operator.

2 SYSTEM DESIGN

Partial class diagram of the software is shown in Fig. 1. MM_AppWindow shown in the figure is the main class of the application program. It has the model which is under construction (MM_Model), various tools (MM_Tool) and so on.

The system uses a technique, similar to traditional ray casting, called volume slicing, to render volumetric images. It can produce a projected image at interactive frame rate with dedicated texture mapping hardware. Results of ray casting and volume slicing are identical [1]. The system permits the user to choose the sampling surfaces during run-time from planes parallel to the view port and planes that are aligned with the primary axes of the voxel cube.

3 IMPLEMENTATION

Currently, the software runs on Debian GNU/Linux PC with Millennium G400 graphics adaptor, and SGI ONYX2 Reality Monster with or without Fakespace, Inc.'s Immersive Work Bench, which is a 90" [2.28 m] diagonal display. We used GNU C++ Compiler and MIPS Pro C++ Compiler, Mesa and OpenGL for 3D graphics, and FLTK as a GUI tool kit.

4 RESULTS

Modeling operations, such as scaling and rotating volumetric images or modifying polygonal meshes rendered over volumetric images, can be done at interactive frame rate on both hardwares. However, the sampling surfaces must be axis aligned on PC + G400 based system since G400 has no hardware support for 3D texture mapping. So, it doesn't provide good results as 3D textures especially when the data slices are canted 45 degrees from the view direction.

ONYX2 Reality Monster has hardware support for 3D texture mapping and two useful OpenGL extensions which are GL_EXT_blend_color and GL_EXT_blend_minmax. Hence operations can be done at interactive frame rate even if the sampling surface is set to view port aligned. The blending can also be used in attenuate or MIP (Maximum Intensity Projection) mode. Modeling can be done in stereoscopic view environment with Immersive Work Bench as well.

The user interface of this system is shown in Fig. 2. We constructed a geometry of the human aortic arch based on MR 3D images (256 * 256 pixels * 112 planes) with this system. This geometry was then used to perform blood flow calculations (Fig. 3).

We will continue further development to make a rapid modeling system based on clinical data. Our current development focus is in the areas of haptic user interface, multi resolution mesh editing, and effective grid generation.

References

[1] Technical Publications, Silicon Graphics, Inc. *OpenGL* (R) *Volumizer Programmer's Guide*. Document Number 007-3720-001.

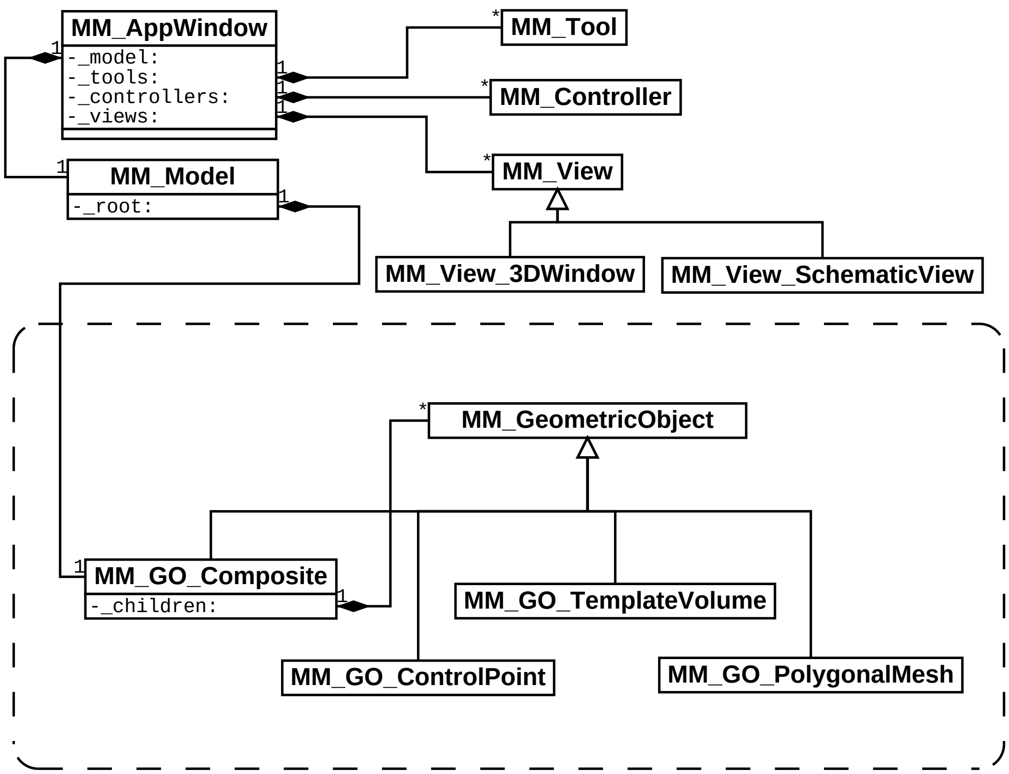

Figure 1: Partial class diagram of the software

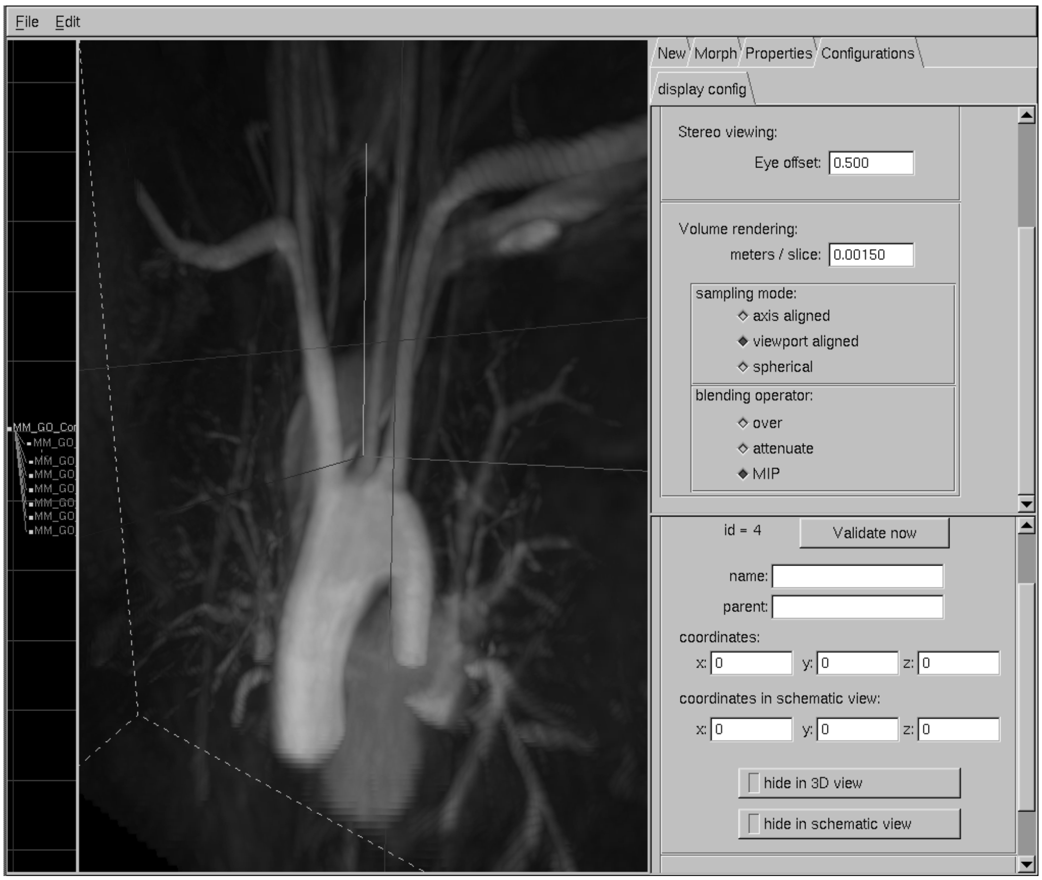

Figure 2: User interface of the modeling system

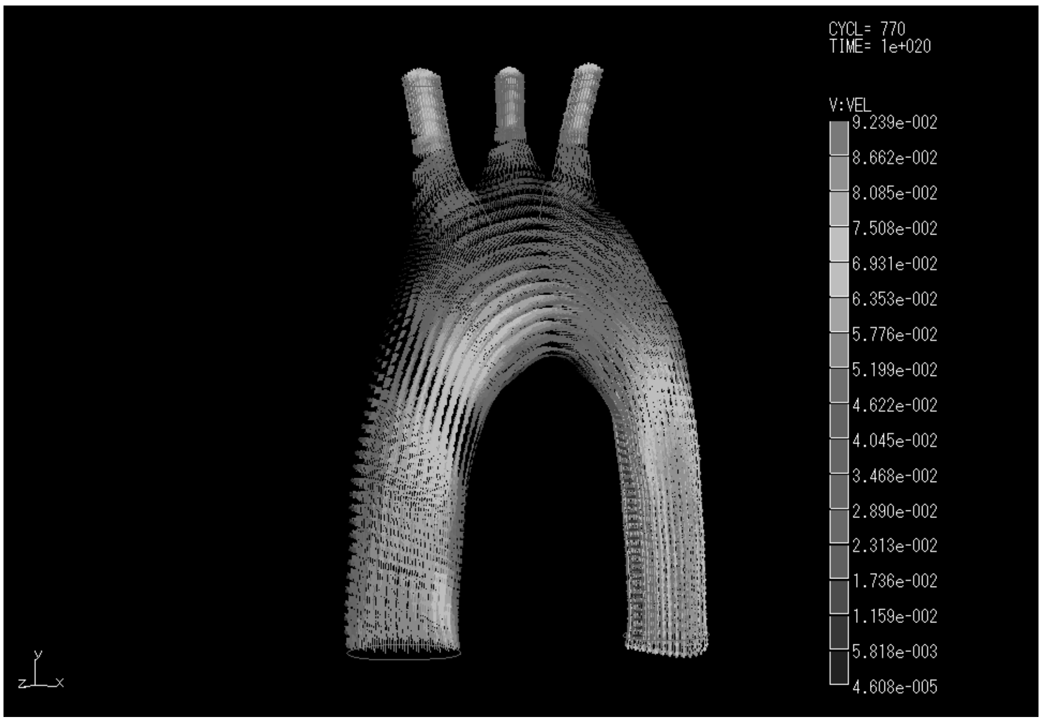

Figure 3: An example model constructed with the system