An Overview Of Immersive Scientific Visualization

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1. Introduction

Scientific Visualization is the Visualization of scientific phenomena. That includes he visualization of flow, particles, terrain, volume and tensors. The purpose is to enable scientists to understand, illustrate and get insight from their data. The data is often very large and most of the time 3D. The use of stereoscopic images can improve the depth cue and the perception of the spatial relationships which might be crucial for scientist when analyzing data.

Virtual reality can give us a sense of presence or immersion in an 3D environment. It is a class of computer-controlled multisensory communication technologies that allow more intuitive interactions with data and involve human senses in new ways. Nowadays head mounted displays (HMDs) like Oculus Rift1 or HTC Vive2 are widely available. That is one way to experience VR. Another Way are systems like the CAVE. It is an immersive virtual reality environment where projectors are directed to between three and six of the walls of a room-sized cube. It uses motion capture system, which records the real time position of the user,for interaction. When using VR for Scientific Visualization the scientists can explore the data in a more direct way which might lead to insights they would otherwise not get.

2. Difficulties in This Field

2.1. Processing Data:

In immersive VR, exploring in a high complexity or a high dimensionality modern data set is difficult. Collaborative investigating in abstract representation of high-dimensional data and feature spaces is even harder. More advanced techniques should be introduced to view feature vectors in a space of tens to hundreds of dimensions.

2.2. Rendering:

General challenges in VR are stereo rendering, the high rendering quality and high frame rates of 90 fps to avoid nausea. Because of these reasons applications reduce precision and density to match the criteria. Thinning respective point clouds or converting them to 3D meshes are a way to go. In [A Point...] performance optimization techniques that speed up the rendering pipeline for 3D point clouds and image optimization techniques that improve image quality are introduced. In [Visualizing large-scale..] they used a distributed, image-parallel algorithm to perform volume rendering of electron density fields and to ray-cast ball-and-stick glyph in one pass to speed up rendering for large-scale Molecular Dynamics simulations.

In [Immersive Molec...] they used a 2-phase rendering system that combines omnidirectional stereoscopic ray tracing with high-performance view-dependent rasterization to provide one or multiple users with high-quality immersive visualization. When viewing primary representations of molecular, the performance of the system is significantly degraded with increasing amount of atoms and bonds model. The approach will be infeasible when it increased to the tens of thousands. To solve this, the author of this article [1] implements the system with GPU instance rendering method in Unity3d engine. But it is still not good enough.

2.3. Interaction:

Tracing labeled neurons manually is time-consuming, may require months to reconstruct even small portions of the brain. It is more challenging working with image slices with fixed viewpoint. Tools such as Vaa3D and NeuroLucida 360 also have their drawbacks. A better tool with immersive environment for tracing should be build.

2.4. Displaying:

Current visualization tools are often incompatible with large screen multiuser display formats with stereoscopic 3D applications generally running an order of magnitude slower than on high end desktop PCs. Thus, faster displaying algorithms specialized for large screens should be introduced.