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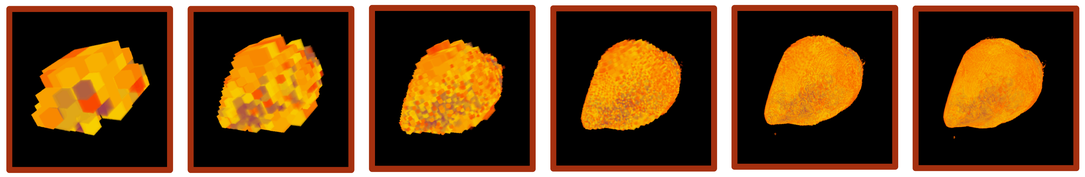
Introduction

The amount of data produced by researchers in fields like nuclear engineering, materials science, and medicine has dramatically increased in recent years. There is a growing need to analyze and visualize this data in order to derive new insights. However, creating a visualization of data that is many gigabytes in size in real time is a difficult task since most graphics processing units (GPUs) are unable to hold this much data at one time. In order to alleviate this issue, an adaptive volume visualizer has been developed that is capable of rendering large scale datasets with high levels of detail at interactive frame rates.

Visualization Algorithm

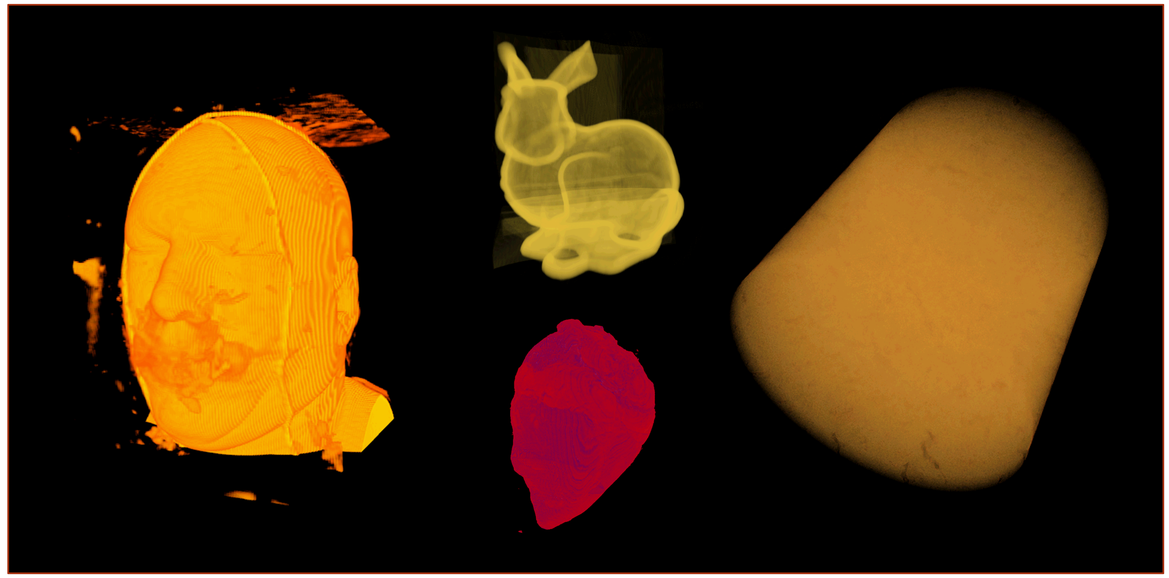
To visualize large amounts of data with high fidelity, a process called ray marching is used. For each pixel of the display, rays are projected into the scene and are checked for intersection with the data volume. If such an intersection occurs, data points are iteratively sampled along the ray through the volume and composited to produce a final pixel color.

In order to access the data efficiently, it is stored in a custom format known as hierarchical Z-order. This format allows for fast input and output times when reading the data and supports adaptive subsampling. This means that the amount of data in GPU memory can be quickly increased and decreased based on how much is actually needed for a high quality visualization.



Level 2 | Level 3 | Level 4 | Level 5 | Level 6 | Level 7

The visualization fidelity of the sheep heart dataset shown above increases as the hierarchical Z-order level increases.



*A set of volume visualizations created with this software. **Left**: A scan of a human head. **Top center**: Stanford bunny dataset. **Center bottom**: A scan of a sheep heart. **Right**: The Gray Rot dataset, which is compromised of approximately 27 billion points and is 42 gigabytes in size.*

Implementation

This software was built with Unity 3D, a commercial game engine that is widely used across industries for visualization and interaction purposes. It supports GPGPU (general purpose GPU) programming through the use of compute shaders. This provides access to the highly parallel processor that is perfectly suited for efficiently visualizing data with the ray marching algorithm. Additionally, software built with this game engine can be published to a wide variety of devices including traditional desktop computers, mobile phones, and immersive environments.

Results

Using this adaptive volume visualization tool, it is now possible to render large scale datasets, such as the Gray Rot dataset, in real time at a high level of detail. The Gray Rot dataset is approximately 42 gigabytes in size with approximately 27 billion data points and was previously not viewable on older systems at the Idaho National Laboratory due to the memory limitations of the software.

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