Interactive Visualization for Aero-Acoustic Analysis in Sibilant [s]

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Introduction

This work presents a study of flow characteristics of sibilant [s] (Fig. 1) using a three-dimensional flow visualization provided by a Large Eddy Simulation (LES). We visualize volume data with Particle-Based Volume Rendering (PBVR)[1] to observe three dimensional structure of the result of the LES. While the PBVR enables fast transparent rendering to treat large-scale unstructured volume data, its computational cost in a preprocessing step can become a bottleneck in concurrent simulation and real-time rendering.

In this poster, we describe a customized PBVR for real-time simulation, a visualization technique for time-series data, and interactive rendering parameter settings to observe the volume data. We also report on new scientific findings obtained by our visualization system.

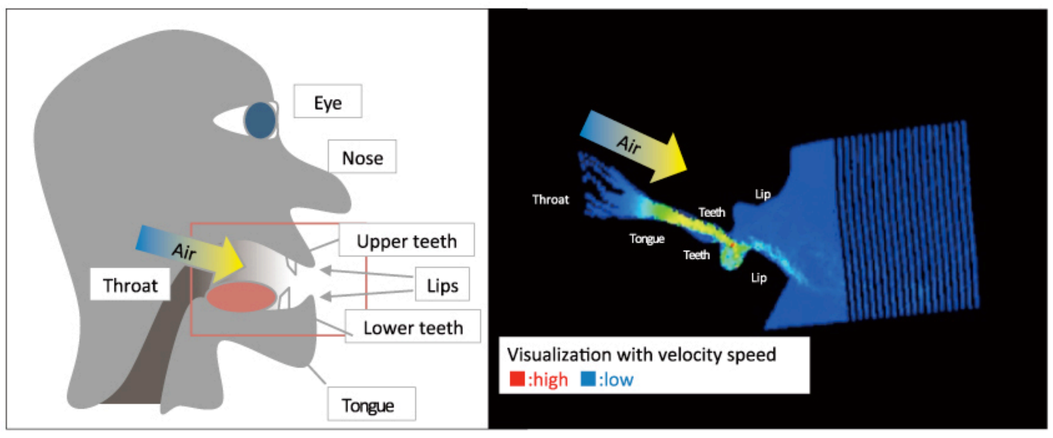

Figure 1: Turbulence Flow in Oral Cavity

Simplified PBVR

The PBVR generates particles by using a density function in a preprocessing step. To reduce the computational cost of the preprocessing step, the Simplified PBVR does not generate particles. instead it simply uses computational mesh vertices as points to render. The Simplified PBVR enables fast preprocessing so that concurrent simulation and real-time rendering. Visualization results have some artifacts reflecting mesh structure (Fig.2). However, the rendering results of the central region of the volume data are comparable to those by a conventional PBVR as its mesh density is high and uniform enough to get a good transparent effect. The Simplified PBVR provides interactive frame rates (73.53fps) for our target volume data (3.69 million particles) with a commercial machine. (Intel Xeon @3.20GHz CPU, 8.0GB RAM, and Quadro 5000 GPU.)

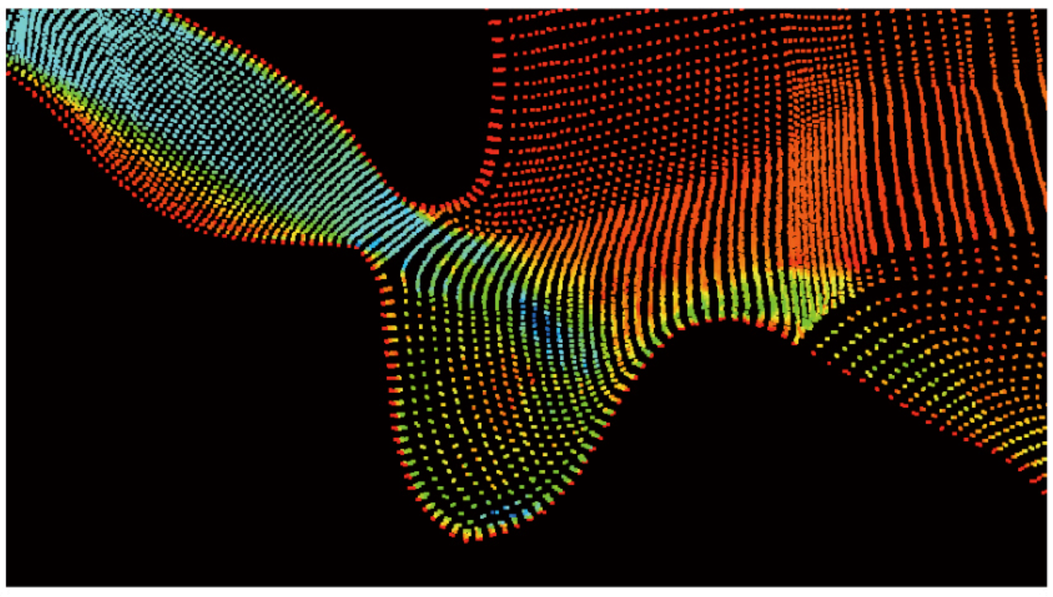

Figure 2: Visualization Result in Simplified PBVR

Interactive Parameter Setting

In time rendering, it' s desirable to render each frame within a fixed interval, since our target volume data is generated by a simulation model based on constant time. We apply a time-critical rendering technique to control rendering time. Specifically, a number of particles drawn is modified to render within a certain amount of time. Figure 3 shows the results of time-critical rendering.

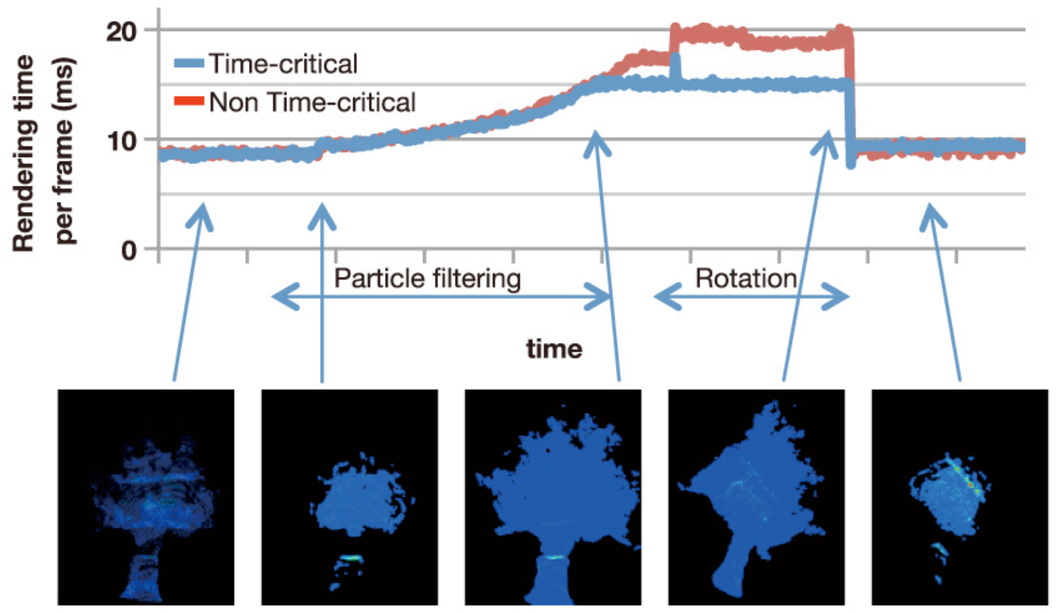

Figure 3: Time-critical Rendering

Visualization of Time-series Volume Data

For efficient observation of the volume data, rendering parameters should be applied immediately. By using a GPU and CUDA, our application allows for the changing of visualization parameters in real-time. For example, selecting a part of the volume data, moving the selected part (Fig. 4), temporarily hiding of a part of the volume and so on. Color mapping can also be directly changed in real-time.

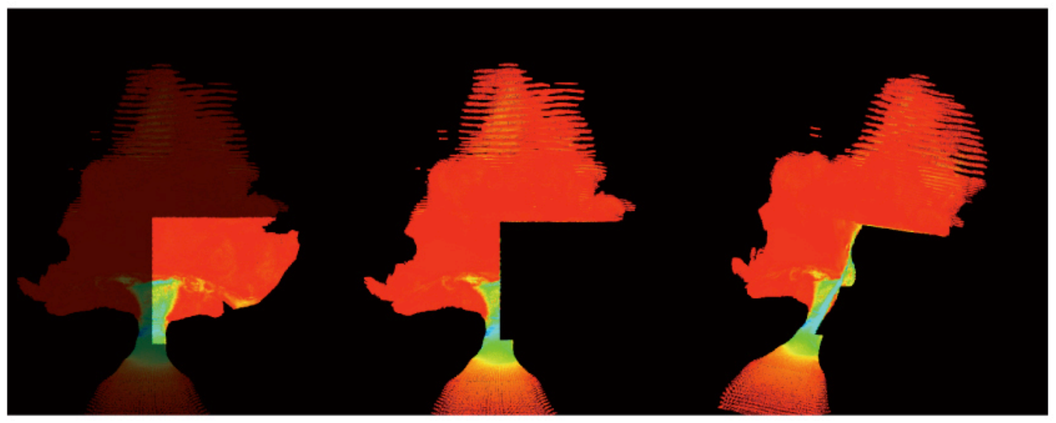

Figure 4: Interactive Parameter Setting

Scientific Findings

Using our visualization system, we made some new scientific discoveries. Figure 5 shows that the fluctuating jet is being generated at the constriction between the base of the tongue and the upper jaw.

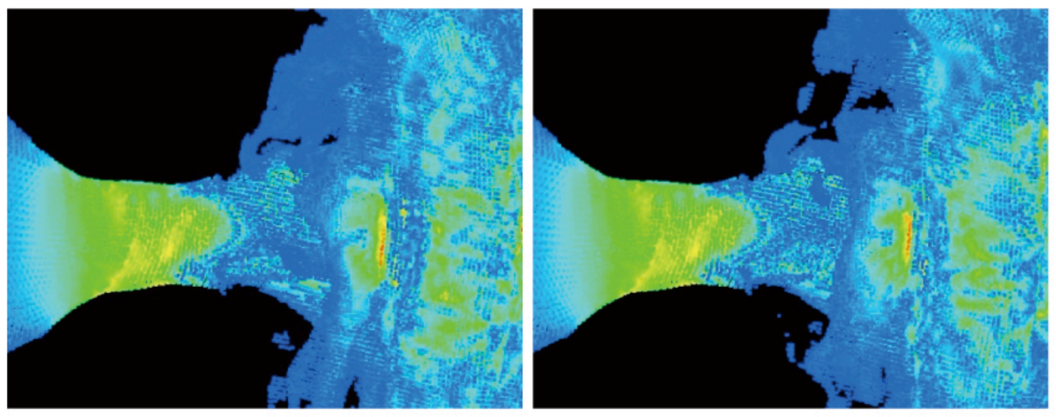

Figure 5: Fluctuating Jet on Tongue

Conclusion

We proposed an interactive visualization system for large-scale volume data. As future work, we are planning to control not only rendering parameters but also real-time simulation parameters such as mesh structure and oral cavity shape.

[1] Z. Ding, T. Kawamura, N. Sakamoto, K. Koyamada: "Particle-based Multiple Irregular Volume Rendering on CUDA," Simulation Modelling Practice and Theory, 2009.

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