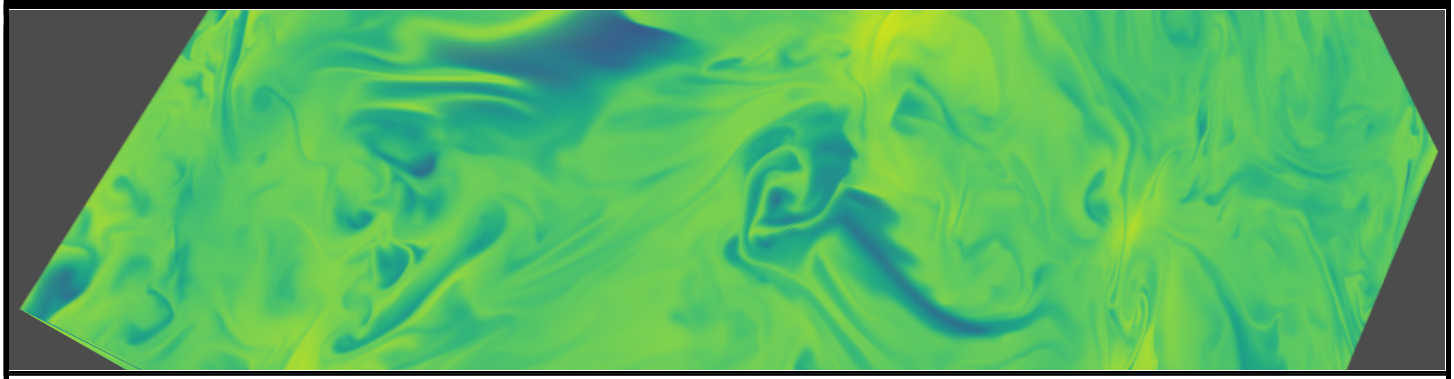
Project: Interactive Real-Time Volume Rendering in VR

University of Zurich[UZH]



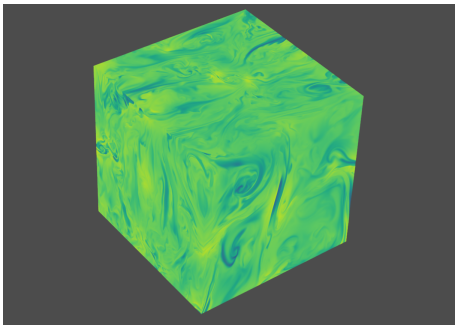
Introduction

In the current age of big data, not only methods like machine learning help us to understand generated or collected data. Approaches that focus on visual representation support users in detecting patterns and getting an overall intuition of their data. Volume rendering, as used in scientific visualization, comes, of course, with its specific challenges.

On one side, there are the visualization related questions. How do we need to display data to allow a domain expert using our tool to gain new insights and help drawing the right conclusions about the data? What are appropriate interaction methods with the data? On the other side, there are technical limits and engineering challenges. How can we seamlessly show gigabytes of data in fractions of a second? How do we need to (pre-)process this data to be prepared to react to user input in real-time?

VR googles with interaction tools. Source: theverge.com.

Head-mounted Virtual Reality (VR) displays offer a very intuitive way of inspecting spatial data. The head can simply be moved instead of using mouse or keyboard to direct the gaze to a different spot of the data. In addition, two tracked interaction handles with buttons can be carried by the user. This set up allows for a complete focus on the data itself and spending all the attention on visual data inspection. Also it opens up new possibilities of interaction, for instance to define arbitrary cutting planes through a volume. Imagine a meteorologist virtually *standing in the middle* of a hurricane or a physician *inside* a patient having a look at a 3D CT image for which these interaction techniques can be very beneficial.



Pressure data set of a hurricane with around 134 million data points visualized by a volume renderer.

When it comes to volume rendering, we are facing a computationally heavy task. So we must carefully think about what to spend the CPU/GPU time on, especially because the rendering should be real-time and interactive. There are mathematical technical methods such as data compression that can be exploited as well as cleverly engineered data structures and implementations, that e.g. can minimize expensive data transfers to the GPU or that omit small details, which humans are unlikely to perceive or are not relevant for the particular problem.

Assignments

The goal of this project is to implement a tool for interactive 3D volume exploration using VR goggles. Besides rendering a volume, interaction tools such as moving cutting planes, changing transfer functions, filtering, or simple selection of volumes are to be implemented. Extensions beyond the basic visualization and interaction can include time-dependent volumes, e.g. to observe a hurricane developing over time, or using really big datasets which do not fit into memory in raw format or are just too big to be processed in real-time.

Project Type

This project can be a bachelor thesis or master thesis through adjusting the tasks and goals.

Requirements

A solid Computer Graphics background is required. Advanced Computer Graphics skills are an asset. C++ and OpenGL will be used heavily, good knowledge and/or high motivation to learn them is required.

Work Load

- 20% Theory
- 70% Implementation
- 10% Test

Supervision

- Prof. Dr. Renato Pajarola
- Pascal Forny (assistant)

Contact

Write an Email to forny@ifi.uzh.ch to have a chat if you are interested and would like to know more about this project.

VISUALIZATION AND MULTIMEDIA LAB

Professor Dr. Renato Pajarola
Visualization and Multimedia Lab
Department of Informatics
University of Zurich