Using virtual reality to analyze multi-dimensional data sets

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Abstract

Virtual reality's fundamental feature -- immersion -- makes it ideal for analyzing complex, multi-dimensional data sets. With virtual reality (VR), researchers are immersed into virtual representations of their data that they then explore using VR goggles and controllers, allowing the researcher to move anywhere and look in any direction within their data. The researcher can then identify features that are not possible with traditional, flat-screen visualization methods, making VR research tools particularly useful for analyzing complex data sets. In this poster, we will present our two VR research tools, one for 3D data sets and or for arbitrary phase-space data. The former gives the researcher the feeling of being in their time-evolving simulations as it runs, while the latter allows up to 8-dimensional phase space at once. We aim to establish new collaborations with other researchers interested in analyzing their data in VR, as well as meet other researchers working in VR.

Virtual Reality Details

Key features of VR:
1. Move anywhere within data set
2. Look in any direction within data set
VR allows a researcher to immerse themselves in their data

Steps for VR development
1. Create virtual representation of data set
2. Program interactivity and analysis tools using the VR headset and controllers

Our development
1. Unity – game engine repurposed to import & explore data
2. SteamVR – package that handles the coordination of hardware and software
   – handles the back end so we focus on data-set importation and analysis-tool creation

Bonus feature:
VR is also great for outreach
– presents data in a novel way
– minimal extra steps to go from a research tool to an outreach product
   – simply pare down the functionality

Looking for data sets to VR

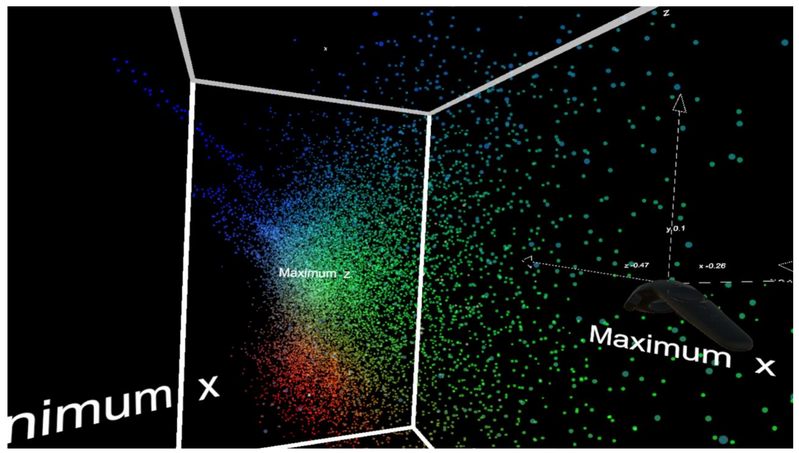
Have a multi-dimensional data set that you are interested in exploring in VR? We are interested in hearing from you!

VR Product 1: Phase Space VR

Goal: Explore multi-dimensional data sets in a manner that leverages the immersive qualities of VR

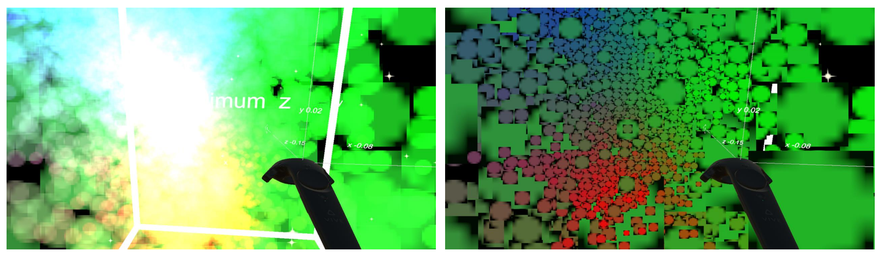
8-dimensions of phase space at once:
– each element in the data set gets a marker
– markers have 8 options: 1 dimension ↔ 1 marker option
Dimensions 1-3: 3 spatial axes of the virtual environment
Dimension 4-6: RGB colors of the marker
Dimension 7: size of the marker
Dimension 8: shape of the marker
– discrete quantities: circle, triangle, square, etc.
– continuous quantities: upward pointing triangle → diamond → downward pointing triangle

Case Study: BPT diagram
– diagnostic of ionization of galaxies



View from inside the VR headset

Switch between projections through the data set (left) and making each marker opaque (right)

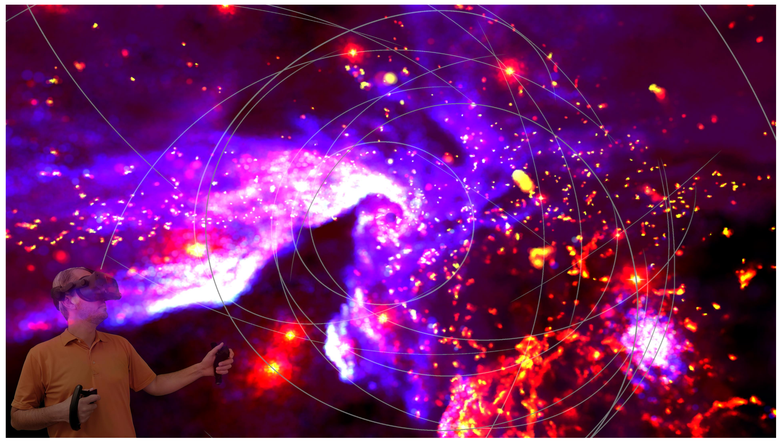


VR Product 2: Hydro VR

Goal: Explore 3-D data sets in a manner that leverages the immersive qualities of VR

Key feature: 3 spatial dimensions of the model correspond to 3 spatial dimensions of the VR representation
– marker size is now tied to spatial extent of each element
– color and shape of markers show various other properties, e.g., density, temperature, X-ray emission, etc.

Case Study: Hydrodynamic simulations of the Galactic center
– contains supermassive black hole, orbiting stars, and stellar winds



View from inside the VR headset

Outreach example: **Galactic Center VR**
– explore 500 years of evolution at the heart of the Milky Way

Published on the Steam and Viveport VR stores for free

Galactic Center VR links:
tinyurl.com/gcvr-steam
tinyurl.com/gcvr-viveport

Requirement: PC-based VR
In progress: version for stand-alone VR