About the Project

Ocean models help us to understand and predict a wide range of intricate physical processes that make up the atmospheric and oceanic systems of the Earth. Because these models output an abundance of complex time-varying three-dimensional (i.e., 4D) data, effectively conveying the multitude of information produced by a given model poses a significant visualization challenge.

Recent advances in mobile computing have ushered in a new era of affordable, high-fidelity virtual reality (VR) devices. The proliferation of these devices presents a unique opportunity to incorporate their use into scientific workflows; especially those involving geospatial data.

Head-Mounted Displays (HMDs) provide a separate view of the virtual scene to each eye, which changes based on the position and orientation of the HMD in physical space to match real-world viewing. The binocular viewing contributes stereopsis and the head tracking enables motion parallax, both of which convey strong depth cues to the human visual system. In addition, they provide a natural and intuitive way to change the viewing position, a task which is normally mapped to a mouse or keyboard function.

Six-Degree-of-Freedom (6DOF) devices that report their position and rotation with respect to a reference coordinate system. The total degrees of freedom can be determined by counting the principal axes (x, y, z) that a device an be positioned along or rotated around. A traditional computer mouse, for example, only reports the relative x- and y-offsets of the mouse position on a desk or mousepad, yielding 2DOF. A device capable of 6DOF provides data about its position and orientation in 3D space.

The kinematic chaining model of bimanual actions proposed by Yves Guiard posits that the left and right hands form a kind of kinematic chain and the non-dominant hand forms a local, coarse frame of reference which the dominant hand can leverage for finer, more precise movements.

An example of this type of asymmetric action would be painting a figure by holding it in one hand and applying the fine details with the other. Past evaluations have found this mode of interaction to be superior over unimanual ones for a variety of tasks in virtual environments.

By combining these superior viewing conditions and interaction techniques, we believe that we can improve the exploration of model results to more quickly and efficiently assess their validity and gain a more holistic understanding of the model.

Visualizing the Great Bay Estuary, New Hampshire

The user could also use a World in a Miniature (WIM) style interaction, where a scaled-down model of the particle system can be held and manipulated using the non-dominant hand and the dominant hand can do more precise work, like placing dye pots in areas of interest or probing the flow velocity at ground-trotted locations to quickly assess the model’s quality. Any visualizations or interactions occurring on the WIM would also be displayed in the larger particle system in the virtual environment.

The Piscataqua River-Great Bay estuary is located in southeastern New Hampshire, and is an important economic and ecological resource to the region. It is influenced by the Gulf of Maine, with large semidiurnal tides, a tide range on the order of 2 meters and tidal currents that can reach more than 2 m/s. Observational datasets (1975-2016) exist throughout the estuarine system and give insight to interesting tidal dynamics. A three dimensional hydrodynamic model is employed to better spatially and temporally resolve these tidal dynamics (especially in areas hard to observe – navigational channels and tidal mudflats). [Cook 2016]

Technical Details

Our dataset is a Regional Ocean Modeling System (ROMS) model representing a 12-hour tidal cycle of the currents within New Hampshire’s Great Bay estuary. The model data was loaded into a custom VR particle system application written in C++ using the OpenVR software library.