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A visualization tool for Yin-Yang grid data and virtual reality visualization of frozen-in vector fields

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We have developed the following two visualization tools and methods. Details will be reported in the talk.

(1)
We have developed an interactive visualization software, ”SV4” for Joint Project for Space Weather Modeling (JPSWM) project. One of characteristic features of SV4 is that it visualizes data defined on a spherical grid system named Yin-Yang grid. Although SV4 is developed as a part of JPSWM project, it can be used in other projects that make use of Yin-Yang grid. Since Yin-Yang gird is now widely used in various fields in geophysics and astrophysics, SV4 would be useful for them, too. Another characteristic feature of SV4 as a visualization software is its base programming language. SV4 is coded in Fortran90 with a graphics library f90gl which is a Fortran interface for OpenGL and GLUT. Having found that most researchers involving JPSWM project use Fotran90/95 and they are not familiar with C/C++, which are standard languages used in computer graphics, we have decided to develop a fully Fotran-based visualization tool and provide the source codes in order that the simulation researchers can customize them. SV4 displays magnetic field lines with their releasing points from which magnetic field lines are integrated. The user can control a releasing point by the mouse drag. The magnetic field line is calculated in real time and shown on the screen. SV4 can visualize scalar fields by the isosurface method. The isosurface level is interactively controlled by the mouse drag. One can rotate, translate, and zoom in/out the visualized 3-dimensional objects in the display window. Another visualization method for scalar data implemented in SV4 is the ortho-slicer in which distribution of the scalar is shown by color contours on x-y, y-z, and z-x planes.

(2)
To analyze three-dimensional data of computational fluid dynamics and mag- netohydrodynamics (MHD), a new visualization method based on virtual reality (VR) technology is developed. In this method, a ”tracer line” is transported or advected by the target flow in three-dimensional VR space. Observing its deformation process, one can intuitively understand the flow’s structure, especially the stretching and twisting components. Since a tracer line is identical to a line of force of a vector field that is frozen-into the flow, the VR tracer line method proposed in this study can also be regarded as a new visualization method for the frozen-in vector field such as magnetic field in the ideal MHD or vorticity field in the Euler fluid. A program named TubeAdvector is developed for the implementation of the VR tracer line method. In TubeAdvector, its initial condition or the initial curve of a tracer line is intuitively specified by moving a portable controller or a 3D mouse in the VR space. The initial curve is then released to be advected by the target flow to be analyzed. When a distance between a pair of consecutive points becomes larger than a pre-defined length, a new point is inserted between them. Since the stretching and twisting components of the flow are key features of the magnetic field generation process in the MHD, the VR tracer line method is useful to analyze geodynamo or solar dynamo simulations. A problem of the VR tracer line method is that it does not convey local flow information around the curve. To resolve this problem, wheel-like objects are added to the tracer line. Radial change of a ring in each wheel shows the divergence component of the flow away from the tracer line at that position. Local colors of the tracer line and their temporal change convey stretching rate of the tracer line there. The original TubeAdvector and the improved one named wTubeAdvector are tested on three kinds of analytically defined flows as well as output data of a geody- namo simulation, and the usefulness of the VR tracer line method implemented by TubeAdvector and wTubeAdvector is confirmed.

Keywords: data visualization, Yin-Yang grid, virtual reality