3D Scalar and 2D Vector Field Visualization An Insight Report

CS732: Data Visualization

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***Abstract*—Numerical simulations of the first stars in the universe reveal that they formed in isolation several hundred million years before the first primitive galaxies were assembled and that they were very massive: 100 - 500 solar masses.**

***Index Terms*—Ionization Front, Mapping, Animation**

I. Introduction

Numerical simulations of the first stars in the universe reveal that they formed in isolation several hundred million years before the first primitive galaxies were assembled and that they were very massive: 100 - 500 solar masses. With surface temperatures greater than 100,000 K they were millions of times brighter than the sun, with most of their light in the form of hard (energetic) UV radiation. These UV photons advanced behind an abrupt wall of radiation known as an ionization front (or I-front) at well below the speed of light. The I-front itself is the extremely thin layer separating the hot (20,000 K), completely ionized gas from the cold (72 K), neutral gas beyond the front. The shock driven by the radiation front snowplows ambient gas into a dense layer that can erupt in violent dynamical instabilities.

They want to understand the formation of galaxies, in particular the effect of ”shadow instabilities”, where radiation ionization fronts scatter around primordial gas.

II. Problem Statement

Besides the work mentioned in the introduction, there has been a lot of other work on facial expression synthesis.

1) : For the 2D vector field visualizations, generate streamline visualizations and compare the quiver plots generated in A1 with streamlines.

Q. What are your inferences from the comparison of the visualizations with respect to the effectiveness of visualization?

2) : From your experience in A1, identify a volumetric dataset at a specific timestep and for one of the scalar fields, select 5 isosurface values, and perform isosurface extraction.

Q. Explain your choice of the volumetric dataset (time-step and the scalar field), and that of the isosurface values.

Q. Experiment with transparencies for displaying the 5 isosurfaces simultaneously. What are your learnings? Did the use of transparency improve the visualization? Did the data have isosurfaces as layers that could exploit the use of transparency for improving visualization?

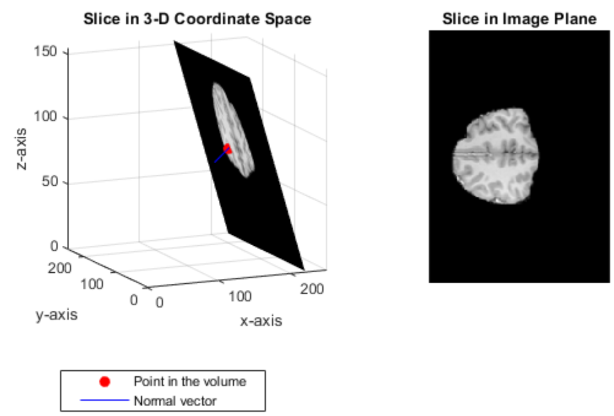

Fig. 1. Outputs of oblique slicing in 3D volumes – (left) in-situ in the 3D volume, and (right) color-mapped image of the cross-sectional view.

3) : Using the volume and scalar field used in 2 in A2, perform oblique slicing. Your program should take 4 values for the plane equation as an input. The slicing plane must be able to move along its axis, i.e. its normal vector through any point on the plane. The visualization output can be presented as a 2D color-mapped image (Fig. 1, right), similar to the outputs in A1; or it could be the visualization of the slice in-situ in the 3D volume (Fig. 1, left).

Q. What is the procedure you have used to make the slicing plane slide along its axis, i.e. the plane normal?

Q. How did you compute the intersection of the slice with the volume?

Q. How is the scalar value computed for the points in the volume, that are not on the grid, for generating the color of the cross-sectional surface?

III. Method

A. Dataset

The subject is an ionization front instability simulation data set submitted by Mike Norman and Daniel Whalen. All simulation data is saved in ASCII format. The data is saved in files with no headers. To enable proper interpretation of the data, we specify the x,y,z dimensions of the mesh and data types that the floating points represent, the units of the data, and the order in which the indices change. There is one such line for every grid point in each file. There is one file per time step in the simulation. The X indices value most rapidly, then Y, then Z; the first line in the file refers to element (0,0,0); the second to element (1,0,0); the last to element (599,247,247). Line format: The values for each grid cell are laid out in a line. Each line has ten values, separated by a single space. There are two types of data here: scalar (temperature, mass density, chemical species), and vector (velocity in km/s). List of scalar data:

1. gas temperature (degrees Kelvin)
2. Total particle density (of particles/cm^3)
3. H mass abundance
4. H+ mass abundance
5. He mass abundance
6. He+ mass abundance
7. He++ mass abundance
8. H- mass abundance
9. H$_2 massabundance$
10. H$_2 + massabundance$

The velocity data set is not of direct relevance to the questions being asked by the scientists, but the magnitude of the curl of the velocity field can be used as an estimator of turbulence, which is of direct interest. The formula for the three components of the curl vector field is:

curl$_x(i,j,k) = (vz(i,j+1,k) - vz(i,j,k) - vy(i,j,k+1) + vy(i,j,k))/0.001$

curl$_y(i,j,k) = (vx(i,j,k+1) - vx(i,j,k) - vz(i+1,j,k) + vz(i,j,k))/0.001$

curl$_z(i,j,k) = (vy(i+1,j,k) - vy(i,j,k) - vx(i,j+1,k) + vx(i,j,k))/0.001$

B. Methodology

1. The data is first taken from the input files to produce images for each of the given time stamps.

2. The images then undergo pre-processing before they can be converted into a ".gif" using the pillow library.

3. The pillow library is finally used to generate the final output.

IV. VISUALIZATIONS

A. Part-1

For the 2D vector field visualizations, we generate streamline visualizations and compare the quiver plots generated in A1 with streamlines.

The inferences from the comparison of the visualizations with respect to the effectiveness of visualization are....

B. Part-2

From our experience in A1, we identify a volumetric dataset at a specific timestep and for one of the scalar fields, we select 5 isosurface values, and perform isosurface extraction.

Our reason for the choice of the volumetric dataset (time-step and the scalar field), and that of the isosurface values is ...

The transparency improved our visualization.

C. Part-3

Using the volume and scalar field used in 2 in A2, we perform oblique slicing. The program takes 4 values for the plane equation as an input. The slicing plane was be able to move along its axis, i.e. its normal vector through any point on the plane. The visualization output is presented as a 2D color-mapped image (Fig. 1, right), similar to the outputs in A1; or it could be the visualization of the slice in-situ in the 3D volume (Fig. 1, left).

The procedure used....

How did you compute the intersection of the slice with the volume?

How is the scalar value computed for the points in the volume, that are not on the grid, for generating the color of the cross-sectional surface?

V. CONCLUSION

The possibilities of interpretations of the data visualized we have visualized is very large. We have only been able to look at a few of them but they provide us with a lot of information. One of the limitation could be not interpolating the data at greater depths. The reason behind avoiding interpolation is that this is a scientific dataset and interpolation might lead to unwanted inaccuracies. The most interesting part was being able to verify the textbook results. Note: I have used all the data for visualization of the above results.

REFERENCES

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[5] Plotly — Graphics Library — Vector Represntation