An Evaluation of Flow Field Visualization with Internal Views

James Walker,* Jun Ma, Scott A. Kuhl, Chaoli Wang
Michigan Technological University

1 Introduction

One popular area of research in data visualization is using streamlines to display flow fields, which depict the movement of fluids through a space. Most of the research to date has focused on external visualizations; that is, observing flow fields from outside the boundaries of the data set (e.g., Tao et al. [2013]). This research explores the efficacy of visualizing flow fields internally using an algorithm we developed to automatically compute paths through flow field interiors that provide a high degree of useful information.

2 User Study

We conducted a user study to evaluate the effectiveness of our path computing algorithm. We used a design of 2 conditions (directed vs. random paths) X 2 tasks (answer questions and identify critical regions). At present, we have data from 21 users for the directed path and 11 users for the random path.

For each experiment, users were briefed about the basics of flow fields and the tasks they would be expected to perform. They were then shown seven flow field data sets, one for practice and six for evaluation. After each tour, users were asked several multiple-choice questions about features in the flow field, and were then asked to identify as many critical points (sources/ sinks, saddles, and spirals) as they could find within a set time limit. We hypothesized that user performance would be better on all tasks with the directed paths..

3 Results and Future Work

User performance on the multiple-choice question task (not shown) was comparable in both conditions and did not exhibit any statistical significance. However, users performed significantly better in the directed condition on the identify critical regions task, as shown in figure 1. The Kruskal-Wallis test showed that the results are statistically significant ($p < 0.05$) for each data set except two-swirl, which has a p-value of 0.104. From this, we conclude that the directed condition is clearly superior for identifying critical regions in flow fields.

*e-mail: jwwalker@mtu.edu

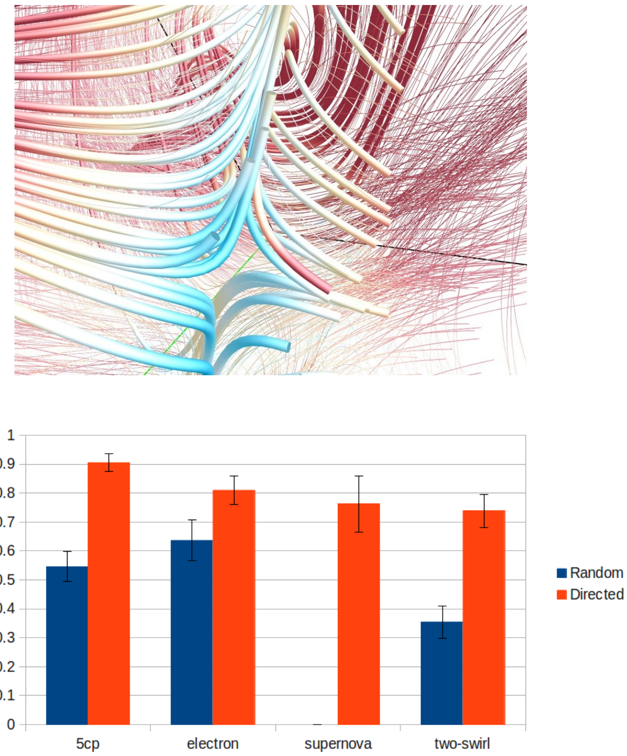

Figure 1. *Screen capture of an interior view of a flow field (top) and proportion of critical regions correctly identified by each user by data set (bottom).*

It is likely that, although random paths do not necessarily provide users with "good" views of flow fields, they still enable the user to see most of the data set. Thus, users are still capable of answering general questions about flow fields. Conversely, some critical regions may lie outside the viewing area or be too occluded to see clearly with a random path, whereas our computed paths deliberately show as many critical regions to users as possible. This would explain why user performance did not vary much on the multiple-choice questions task, but varied significantly on the identify critical regions task.

Current and future work includes comparing path-based flow field exploration against fully interactive exploration where the user has complete control over the viewpoint, and exploring differences between various display devices such as regular desktop monitors versus large display walls.

References

TAO, J., MA, J., WANG, C., AND SHENE, C.K. 2013. A Unified Approach to Streamline Selection and Viewpoint Selection for 3D Flow Visualization. *IEEE Transactions on Visualization and Computer Graphics 19(3)*, pp. 393-406.