Quantifying the Benefits of Artistic Methods in CFD Visualizations: A Pilot User Study

J. Reiter, J. LaViola, R.M. Kirby, D.H. Laidlaw

1 Introduction

Finding useful and accurate techniques for presenting many fields of vector and scalar data is essential for developing good CFD visualization techniques. Recent work borrows ideas from artists to produce such visualizations. In this paper we present the results of a study to determine which classes of CFD problems benefit most from novel artistic methods. We found that people were able to make more accurate quantative comparisons in artistically rendered images. People were also better able to describe relationships among more than 2 fields of data with the artistic images.

2 Methods

Eight Brown University students from quantitative disciplines that did not have significant scientific visualization or CFD experience were selected. Each subject was trained to interpret CFD data using both a traditional method, Tecplot, and a painterly method [1]. Subjects were trained to compare the magnitudes of different quantities, describe the correlations among variables, recognize and count features and locate sources of turbulent disturbances.

Subjects were then asked a series of questions on sample visualizations. Many questions asked the subject to compare the magnitude of one variable among a set of locations. Subjects were also asked to count features like vortices in some images, and determine if those features travelled down the domain with the flow in others. They were also asked questions concerning correlations among up to 3 quantities.

Half of the subjects were shown artistic pictures first and the other half interpreted traditional pictures first. Each group was then presented with the other style and questioned.

3 Results

Subject accuracy was 13% higher for determining where a scalar field's value was greater in artistic images over traditional ones. We also found that subject accuracy was 4% higher for vector magnitude comparisons in artistic images over traditional images. Inter-variable correlation question accuracy was increased by 18% with artistic images.

The fraction of "can't tell" responses to magnitude comparison questions for traditional images was nearly double the fraction for artistic images.

When asked to describe correlations among more than two variables subjects were required to use more than one Tecplot image since Tecplot does not allow more than one scalar and one vector quantity in a single image. Painterly images can handle an arbitrary number of variables and we found that subjects were better able to describe correlations among more than two variables based on artistic data presentations. While accuracy was higher with artistic images, the fraction of "can't tell" responses nearly doubled for artistically presented data.

4 Conclusions

In this study, we have shown that painterly visualization methods allow users to identify correlations in higher dimensional data

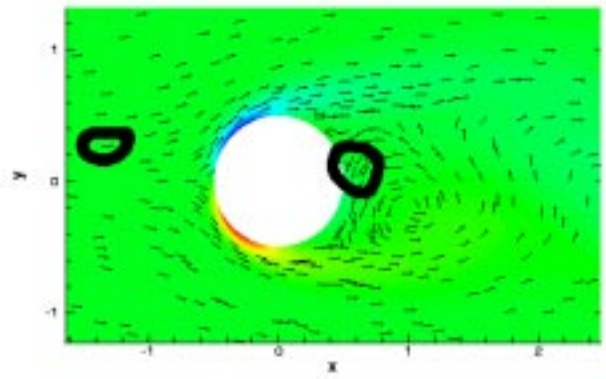

Figure 1: Subjects were asked whether the magnitude of velocity, represented by the arrows, is greater in the central circle or the lefthand one.

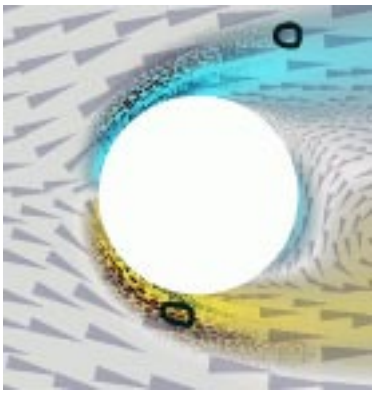

Figure 2: In this artistic image, subjects were asked to compare the magnitude of turbulent charge, represented by the color of small rectangles.

than traditional Tecplot visualizations. The level of confidence, measured through the number of "could not tell" responses, was lower for the painterly images but subjects were more frequently correct. Additionally nearly every subject described the painterly images as cluttered and claimed to prefer the traditional style.

This last result is even more surprising since we found that subjects were better able to make quantative comparisons with the painterly data than with the traditional data.

In short, we found that artistic methods led to more accurate conclusions but that subjects preferred the traditional style.

References

[1] Kirby, R.M., H. Marmanis, and D.H. Laidlaw. Visualizing Multivalued Data from 2D Incompressible Flows Using Concepts from Painting, In *Proceedings of Visualization '99*, October 24-29, 1999.