Neural Modeling of Flow Rendering Effectiveness

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It has been previously proposed that understanding the mechanisms of contour perception can provide a theory for why some flow-rendering methods allow for better judgments of advection pathways than others. In the present article, we develop this theory through a numerical model of the primary visual cortex of the brain (Visual Area 1) where contour enhancement is understood to occur according to most neurological theories. We apply a two-stage model of contour perception to various visual representations of flow fields evaluated using the advection task of Laidlaw et al. [2001]. In the first stage, contour enhancement is modeled based on Li's cortical model [Li 1998]. In the second stage, a model of streamline tracing is proposed, designed to support the advection task. We examine the predictive power of the model by comparing its performance to that of human subjects on the advection task with four different visualizations. The results show the same overall pattern for humans and the model. In both cases, the best performance was obtained with an aligned streamline-based method, which tied with a LIC-based method. Using a regular or jittered grid of arrows produced worse results. The model yields insights into the relative strengths of different flow visualization methods for the task of visualizing advection pathways.

Categories and Subject Descriptors: H.5.2 [**Information Interfaces and Presentation**]: User Interfaces—*Evaluation/methodology*; H.1.2 [**Models and Principles**]: User/Machine Systems—*Human Information Processing*; I.5.1 [**Pattern Recognition**]: Models—*Neural Nets*

General Terms: Human Factors

Additional Key Words and Phrases: Contour perception, flow visualization, perceptual theory, visual cortex, visualization

ACM Reference Format:

Daniel Pineo, Colin Ware, and Sean Fogarty. 2010. Neural Modeling of Flow Rendering Effectiveness. *ACM Trans. Appl. Percept.* 2, 3, Article 1 (May 2010), 2 pages.
DOI:http://dx.doi.org/10.1145/0000000.0000000

1. INTRODUCTION

Many techniques for 2D flow visualization have been developed and applied. These include grids of little arrows, still the most common for many applications, equally spaced streamlines [**?**; **?**], and line integral convolution (LIC) [**?**]. But which is best and why? **?**] showed that the "which is best" question can be answered by means of user studies in which participants are asked to carry out tasks such as tracing advection pathways or finding critical points in the flow field. (Note: An advection pathway is

This work is supported by the Widget Corporation Grant #312-001.
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DOI:http://dx.doi.org/10.1145/0000000.0000000

the same as a streamline in a steady flow field.) **?**] proposed that the "why" question may be answered through the application of recent theories of the way contours in the environment are processed in the visual cortex of the brain. But Ware only provided a descriptive sketch with minimal detail and no formal expression. In the present paper, we show, through a numerical model of neural processing in the cortex, how the theory predicts which methods will be best for an advection path tracing task.

2. DISCUSSION

APPENDIX

Received February 2009; revised July 2009; accepted October 2009

Online Appendix to: Neural Modeling of Flow Rendering Effectiveness

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A. ANALYSIS OF INVALID TRIALS

A.1 Results

A.2 Discussion

DOI: http://dx.doi.org/10.1145/0000000.0000000