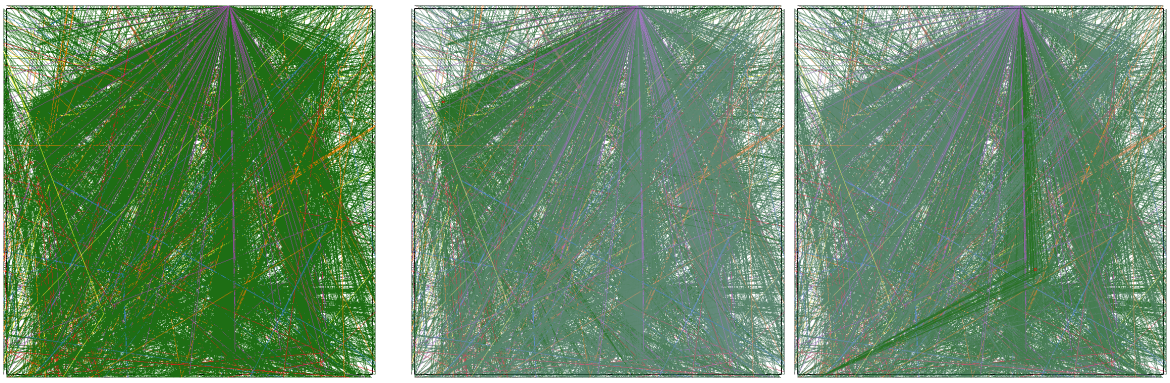
Illustrative Rendering for Information Visualization

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(a) No Enhancement (b) Aerial Perspective

Figure 1: OASC Browser: Aerial Perspective. The shading highlights OASC events near the selected IP addresses while fading those farther away.

Abstract

In this work, we study the applicability of some illustrative rendering techniques to information visualization. Specifically, we study the effect of haloing and aerial perspective. Applications from graph visualization, security visualization, and multivariate visualizations are tested.

Keywords: information visualization, illustrative rendering, non-photorealistic rendering, graph visualization, parallel coordinates

1 Introduction

Due to its focus on the depiction on abstract data, information visualizations are inheritly "non-photorealisic;" informative depiction is valued over approaches favoring realism. In contrast, scientific visualization often requires elements of realism due to the physicality of its data. Recent advances in applying non-photorealistic rendering methods—methods using artistically inspired depictions—to scientific visualization have been shown to effectively communicate features of the data under study. This study applies some of these techniques to information visualization under the assumption that they can help users perform their tasks.

In this study, two examples of "illustrative rendering"—non-photorealistic methods for visualization—are explored: *haloing* [1] and *aerial perspective*. These techniques are integrated into three line-based information visualizations: A parallel coordinates system, a security visualization system, and a focus+context graph system.

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2 Illustrative InfoVis

Two illustrative rendering methods were used in our study: Haloing and aerial perspective.

Haloing is the process of "surrounding" a line or object with a bordering color. For objects, haloing is used to visually communicate significance or to provide separation from the background. The halo increases the contrast of the line or object with the background or other objects; this makes the object easier to perceive [6]. In addition, haloing assists in line depth perception.

Aerial perspective is a specific form of depth shading or depth cueing; it mimics the decrease in contrast caused by increased light scattering as an object recedes into the distance. Artists achieve this effect by blending the original color of an object with a bluish-grey the farther the object is away from foreground plane [2]. For our 2D information visualizations, we induce a false depth depending on the application. In all cases, we use this depth as a measure of importance—"closer" objects are of more *a priori* interest to the user.

3 Test Systems and Results

Three line-based test systems are used to demonstrate the effectiveness of illustrative rendering for information visualization.

3.1 OASC Browser

To assist network analysts, a tool to visualize IP ownership changes was developed [4, 5] (Figure 2, top). The tool uses a quadtree decomposition to represent IP addresses and colored lines drawn from the edge of the quadtree to represent *autonomous domains* (ASes) claiming the IP address. The lines represent transfer of IP address ownership and color represents the type of change.

To assist in understanding the order of events, haloing is used (Figure 2). Events are drawn in the order they are occur within the data; it is assumed that the events are stored in chronological order. Using this order to determine which lines are haloed, there is a clear

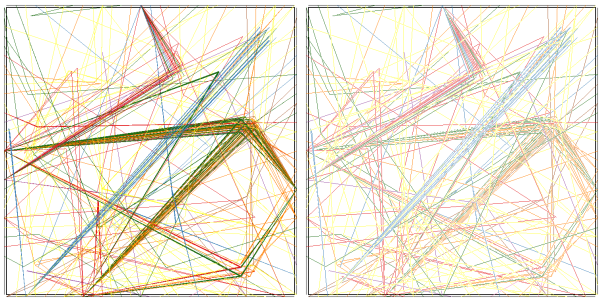


Figure 2: OASC Browser: Normal (left) vs. Haloed (right)

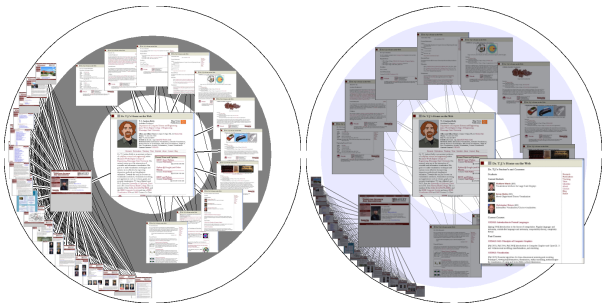


Figure 3: MoireGraph: Haloing (Left) and Aerial Perspective (Right)

separation between the lines; the order is seen pre-attentively due to the Gestalt principle of continuity—the continuity is removed by the background-color gap [6].

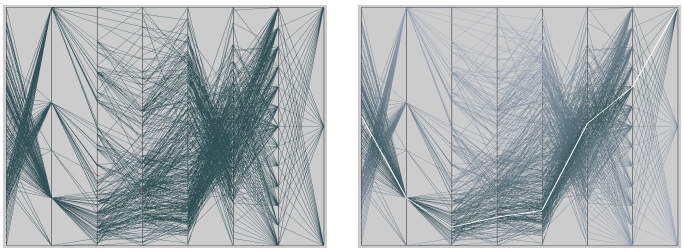
Once an anomaly is found, the affected IP addresses and ASes must be determined. Aerial perspective is used to assist in this task (Figure 1). The distance used for the aerial perspective depth is the separation in the quadtree IP-address space. IP addresses at points farther away from the user's mouse are faded into the "background." Event lines that pass near the focus region but do not involve focus IP addresses will be colored differently (Figure 1, b).

3.2 MoireGraph

The second test system is the MoireGraph [3], a radial focus+context graph visualization technique designed to display visual nodes such as images. The focus node is given the majority of the screen space; each subsequent level is given half the previous space. Other levels or images in the graph can be given a "secondary" focus, and thus more screen space.

Any edge in the visualization is either a spanning tree edge or a graph edge. Tree edges were originally indicated via a bolder, thicker edge; however, line width is not a very strong visual cue, and tree edges were not significantly easier to discern than graph edges. Haloing easily addresses this issue; the discontinuity surrounding the haloed tree edges quickly separates them visually from the graph edges (Figure 3, left).

For the MoireGraph, aerial perspective is used to depict graph structure. Comprehending the graph's structure—such as determining the distance of the secondary focus from other nodes—requires effort. We simplify this effort by using aerial perspective; the graph distance from the sub-focus in the induced spanning tree is used as the artificial depth (Figure 3, right).



(a) No Enhancement (b) Aerial Perspective

Figure 4: Parallel Coordinates: Aerial perspective applied to the focus data line.

3.3 Parallel Coordinates

Parallel coordinates is a multidimensional visualization technique based upon a point-line duality: Each dimension becomes an axis distributed across the display space; data points then become lines connecting the respective data values for each axis.

To assist in trend finding with parallel coordinates, we use aerial perspective (Figure 4, b). For each segment of a line, its signed distance in the pixel plane from the selected line is calculated at its two endpoints; this signed distance is then used by the aerial perspective fragment shader. Using this faux depth, data line segments near the selected line are unaffected while those far away are faded. The luminance change quickly communicates similarity in data trends: If the lines are predominantly faded, then the selected data line varies significantly from the average; if the lines are not faded, then the selected data-line follows the overall trend.

4 Conclusions and Future Work

Illustrative rendering has benefited scientific visualization; in this work, we have demonstrated similar benefits for information visualization. There is significantly more work to be done in this area. There are a wealth of illustrative rendering methods yet to be applied; similarly, there are different visualization methods yet to be tested. Not all illustrative techniques will benefit all visualization tasks, but we feel there are many rewards to be reaped. Effective illustrative visualization applications will require the collaboration of perceptual scientists, cognitive scientists, and artists; this collaboration would enrich all these fields.

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