Whisper, Don't Scream: Characterizing Subtle Grids

Lyn Bartram
Simon Fraser University
lyn@sfu.ca

Maureen Stone
StoneSoup Consulting/Simon Fraser University
stone@stonesc.com

Abstract

Visual elements such as grids, labels, and contour lines act as *reference structures* or *visual metadata* that support the primary information being presented. Such structures need to be usefully visible, but not so obtrusive that they clutter the presentation. Our goal is to determine the physical, perceptual and cognitive characteristics of such structures, ideally in a way that enables their automatic computation. This experiment presents our first results towards characterizing the properties of grids. Specifically, we present the result of a set of experiments to determine effective display ranges, described in terms of transparency (alpha), for thin rectangular grids over scatterplot data.

CR Categories and Subject Descriptors: H.3 [Information systems] Information Interfaces & Presentation, I.3.3 [Computer Graphics]: Picture/Image Generation.

Additional Keywords: Information visualization, automated presentation, applied perception, visual design

1 Introduction

Certain visual elements in many visualizations are used for reference rather than data: examples are grids, labels, and contour lines. These elements need to be accessible without being too obtrusive. Visual designers understand and carefully manipulate this balance between these elements and data in the image. However, this balance is often difficult to maintain in dynamic computer-based visualizations where the amount of information in the image is constantly changing. The general goal of our research is to understand and quantify these subtle aspects of visual representation required in dense information displays such that they can be algorithmically manipulated to match human requirements in interactive and dynamic conditions.

Our approach to this problem is not to characterize "ideal" or "best," but instead to define boundary conditions, outside of which the presentation is clearly bad. We reason that the best solution will always be contextual, as well as a matter of taste. Boundary conditions, however, are more likely to have simple rules that can easily be incorporated by engineers and researchers, and less likely to be influenced by taste.

2 Background

We began our work with grids over maps. Together with visual designer Diane Gromala, we created an interactive tool that allowed the viewer to change the darkness and the transparency of a simple rectangular grid presented over a variety of grayscale map and graph images. People were encouraged to manipulate the color (gray pixel value) of the grid, and its transparency (alpha value). Pilot explorations of this tool at APGV 2006, SIGGRAPH 2006 and Vis2006 [1,2] led us to two boundary conditions for a transparent grid of a fixed line weight and spacing: the point at which it is imperceptibly faint (too light), and the point at which it clearly sits in front of the image, rather than seeming a part of it (too dark) (Several of our participants called this a "fence"). An ideal grid sits between these boundaries.

We designed an experiment to see how accurately we could predict these boundaries. We were especially interested in the darker boundary, for while "too light" seems a simple perceptual metric, "too dark" seemed much more difficult to predict. Our results, however, show that while "the fence" is more image specific than "too light," users are quite consistent about where they set it, suggesting there is a fundamental perceptual and/or cognitive basis for it.

3 The Experiment

For this first experiment, we chose to evaluate a fixed grid with a constant line spacing and line weight (one pixel) over a set of images with different background colors (gray values), and different levels of visual complexity.

Subjects were asked to adjust the alpha value for a black grid over a relatively light background. We chose alpha as our control because this is how experienced visual designers create grids [3,4]. By providing only one variable, we could create a relatively simple interaction based on the motion of the mouse.

We set the subjects to two different tasks. The first was to specify the point where "the grid is just perceptible without being unnoticeable or unusable" (light task). The second was to adjust the grid "to meet your best judgment of how obvious it can be before becoming too intrusive" (dark task).

The subjects performed the tasks as two separate tests; that is, they did all of one task on all of the images, then the other task. All users performed the experiments on the same, calibrated display under the same viewing conditions.

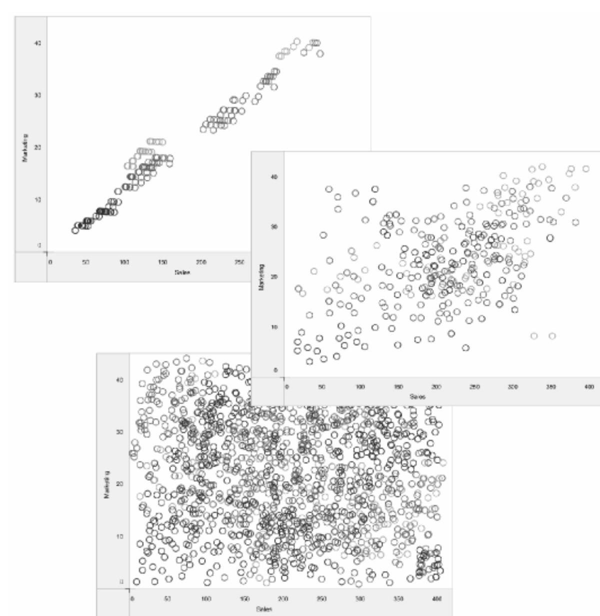

Figure 1. The three test plots: sparse, medium, dense.

SIAT, Simon Fraser University 250-13450 102 Ave., Surrey, BC, Canada

3.1 The images

We created four image types of varying complexity: a flat field (which can be considered "no density") and three scatter plots at different levels of density: sparse, medium and dense (Figure 1). The plots were generated from a dense scatter plot, and then hand manipulated to change the distribution and the number of elements. Each image was displayed over 5 gray backgrounds, ranging in uniform steps from L* = 96 to 60 (Figure 2). The gray values of the foreground circles in the plots are: L*=28, 49, 53, 73. Each plot was rendered as a JPEG image and displayed at a spatial resolution of 800x600 pixels on an Apple Cinema Display.

Figure 2. Background gray values (formatted for sRGB).

3.2 Experimental method

A 4(complexity) x 5(background) factorial design yielded 20 experimental conditions. Each subject performed two separate task blocks, one for the dark boundary, and one for the light. Each task block had 3 repetitions of 20 images resulting in 60 trials/block. Trial ordering was randomized and block ordering was counterbalanced. Twelve university students with normal or corrected-to-normal vision participated in the experiment and were paid.

4 Results

Table 1 and Figure 3 show the results. A two-factor ANOVA revealed a significant effect of complexity in both tasks: $F(3,228) = 60.01152$, $p<.0001$ (light) and $F(3,228) = 11.97885$, $p<.0001$ (dark). Background was not significant.

Table 1. Mean light and dark alpha values (extremes in bold)

	Flat	Sparse	Medium	Dense
60	.0725 .2547	.0763 .2675	.0756 .3306	.1475 .3989
69	.0697 .2553	.0174 .2606	.0861 .3052	.1617 .4392
78	.0686 .2470	.0596 .2808	.0706 .3436	.1520 .4444
87	.0581 .2367	.5181 .3081	.0706 .3261	.1581 .4497
96	**.055** 2261	.0564 .2764	.0703 .3553	.1653 **.5019**

The background is not significant because specifying alpha (rather than the grid gray value) automatically provides contrast with the background. For the case of a black grid, alpha correlates directly with luminance contrast.

The dense image (and to some extent the medium image) show the influence of the foreground complexity, and the relationship between range (the difference between the dark alpha and the light alpha) and complexity is the most statistically significant.

Looking at the graph in figure 3, most subjects found the grid to be usably legible at very light alpha values, even for a complex image. The range defined by our boundary conditions, which is plotted offset by the minimum alpha, increases with complexity, as does the minimum alpha for the dense image.

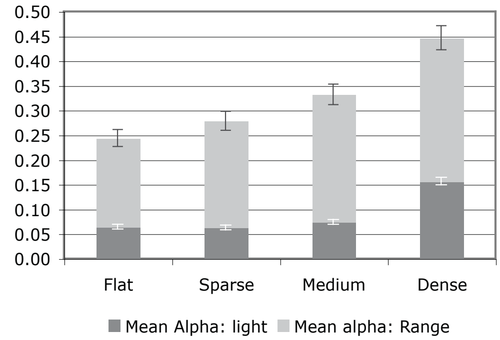

Figure 3. Range and offset for all images.

5 Discussion and Future Work

Our results already have practical implications. For three out of the four cases, a light but useful grid could be created with an alpha value around 0.1, and in all cases, an alpha value of 0.2 falls in the "not bad" range. This is much lighter and more subtle than the solid black grid (alpha=1.0) common in many visualization systems and technical illustrations.

Our metric for complexity is very ad hoc at this point. For this experiment, we wanted primarily to test the hypothesis that for sparse images, contrast with the background would be the dominating effect. Therefore, we designed the cases to cover progressively more of the background. Our results validate the assumption that contrast with the background (encoded by alpha) can be tightly bounded across viewers, and that perception on a flat field is a good predictor for sparse graphs.

The step up in minimum alpha for the "dense" case, and the general increase in range with complexity, illustrate that the foreground complexity can be (as expected) a significant factor. However, people do seem to set as tight a specification for the boundaries for the dense image as for the less dense; they are just in a different place. This suggests that if we can characterize the influences, we will continue to find useful metrics.

This is only the first of many studies. We want to complete our study of simple grids on uncluttered backgrounds, including light grids on dark backgrounds, plus the influence of variables such as line weight and spacing. We want to continue to explore metrics for visual complexity, and their relationship to grid efficacy. For example, high-contrast patterns at a spatial frequency similar to that of the grid line interfere strongly, whereas smooth changes in background lightness have minimal effect. Our broader goal is to explore the characteristics of effectively subtle grids and other reference structures over a wide range of images, colors and tasks. We hope that we can ultimately provide algorithmic approaches to maintaining good design balance in dynamic interactive visualizations.

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