Visualization for Communication: The Importance of Aesthetic Sizzle

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Abstract

When creating a visualization for communication, the inclusion of aesthetically appealing elements can greatly increase a design's appeal, intuitiveness and memorability. Used without care, this "sizzle" can reduce the effectiveness of the visualization by obscuring the intended message. Maintaining a focus on key design principles and an understanding of the target audience can result in an effective visualization for communication. This paper describes these principles and shows their use in creating effective designs.

Keywords--- **visualization, 3D, color, trails, Gestalt, animation**.

1. Introduction

In the field of analytical and referential information visualization, aesthetically novel techniques are often criticized for detracting from the message presented by the original data. However, when a visualization's primary goals include communication, aesthetic details (or *sizzle*) can greatly enhance its potential to communicate. This is because sizzle can add a visceral appeal. Sizzle enhances a visualization's potential to communicate by focusing the desired message and increasing its memorability. When properly applied, sizzle can enhance the communication potential of the graphic; whereas poorly applied gratuitous sizzle can result in a graphic that either misses the message or is even misleading. Evaluating which techniques are appropriate for clarity and accuracy is of the utmost importance when designing a visualization for communication.

What is sizzle? Highlights, 3D, animation, simplification, use of color and other visual effects are often derided by critics with good reason [1] [5] yet continue to appeal to everyday consumers of information graphics (for example, the popular daily snapshot in USA Today).

Consider the following 3D surface:

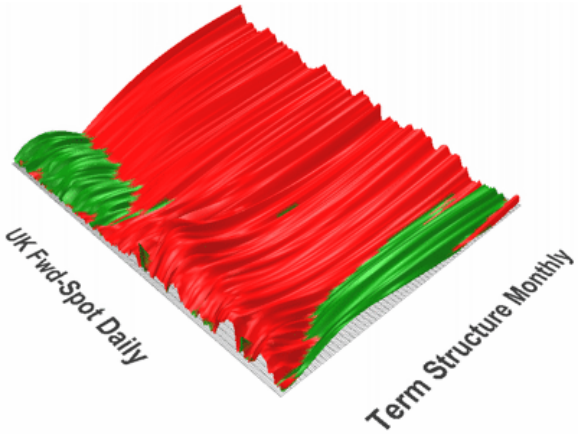

Figure 1 - 3D Surface

The highlights and shading across the surface create a slick image, but do these gratuitous 3D effects add any value to understanding the data? Consider the same data represented with bars:

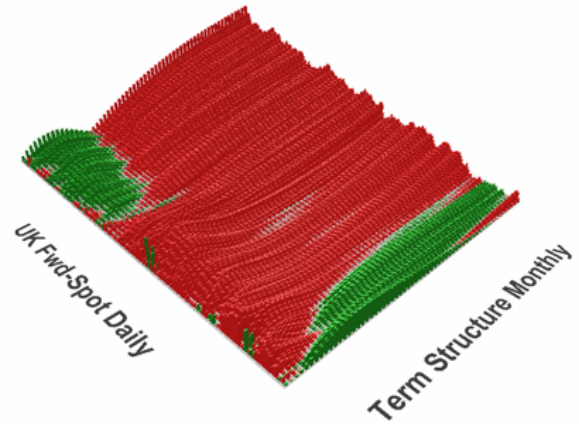

Figure 2 - 3D Bar Chart

The bars represent the same data, but plateaus and ripples are not as easily discerned as they are in the surface representation. The glossy surface *can* provide more insight visually than simple bars.

Is the evaluation of effective sizzle simply a mutually exclusive decision, such as whether or not to use a surface? Consider this example of a heat grid:

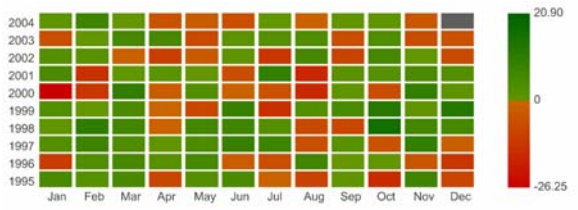

Figure 3 - 2D Heat Grid

Large differences in values are immediately apparent, but subtle differences are harder to distinguish. Now consider the same data depicted in three dimensions:

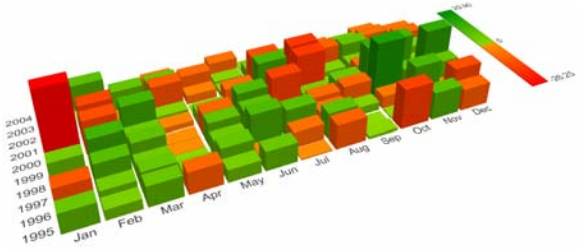

Figure 4 - 3D Heat Grid

3D makes subtle differences more visible, such as the difference between the bar heights in March and April in the first row. But the heights of the bars and the perspective viewpoint obscure many small bars. Is 3D just a gratuitous effect obscuring data? Consider the same 3D chart from a different angle:

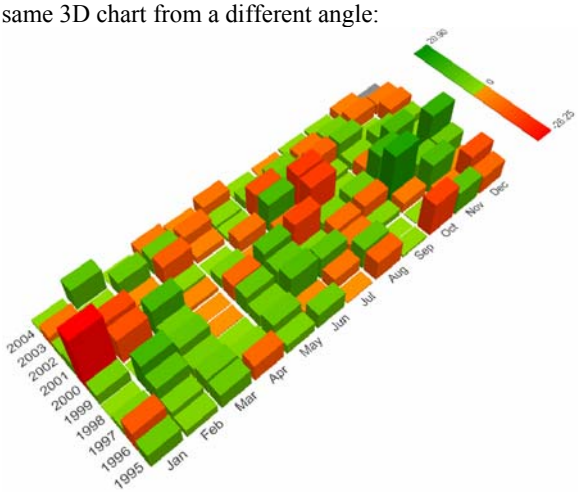

Figure 5 - 3D Heat Grid, Alternate Viewpoint

From this 3D viewpoint, almost all bars are visible, and relative heights can be visually compared. 3D has added value to this visualization, but the issue is not as simple as "3D or not 3D" – rather more subtle parameters such as viewpoint and scaling are key to making the 3D work.

So how does one evaluate "good sizzle"? One way is to evaluate information design similar to how we evaluate good art, good architecture or other design – examples are de-constructed to understand what appears to work; and is used as a basis for a set of guidelines.

2. Background

Poorly thought-out designs can result in detracting elements such as "chart junk" [5] , moiré patterns [4] and visual clutter that reduce or even negate the benefits of an analytic visualization. The principles put forth by Tufte, Bertin and others can be used to reduce these problems and allow the viewer to focus on the data, not the visualization.

When the goals of the visualization include communication, the designer must extend on these principles and incorporate novel, domain-specific elements to facilitate the presentation of the desired message. When dealing with high-dimensional data the visualization must also incorporate 3D interaction design, since it may be impossible to display the information on a two-dimensional surface. In these cases the designer must utilize spatial reasoning to help the observer interact with and comprehend the data.

Effectively communicating the intended message of a complex dataset requires the designer to couple the techniques of information visualization (such as scale, contrast and proportion) with those of interaction design (such as affordances [7] , representation and structure).

3. Key Principles

There are several key design principles that can be used create visualizations that are accurate and concise while remaining aesthetically interesting. The concept of "less is more", as introduced by Mies van der Rohe, is a mantra followed by many in the information visualization world. It is most often practiced in visualizations showing trends in the data, as opposed to analyzing specific details. When the goal of the visualization is to show relative movements (see Figure 10), then obscuring the graphic with a multitude of labels is irrelevant. Only the maximum and minimum of the current range need to be shown, providing a context for the observer. Had the goal of the visualization been to provide an analytic view, then absolute label markers along each axis would have been required.

The incorporation of spatial and color dimensions are primary signifies of data values. Values may be reinforced by correlating spatial position and color, or these two dimensions can be used to represent separate variables, as the color dimension is just as significant as the spatial dimension in imparting information [8] . When choosing between reinforcement and dimensionality, the design must be tailored to the specific domain in which the data exists and to the audience to whom it is being presented. Gestalt grouping principles (used to signify related elements) apply to both location and color, and must be employed in the design of secondary elements so as not to accidentally

give implied meaning [6]. Common aspects such as glyph and label sizes, colors and placement may cause the observer to assume an unintended relationship.

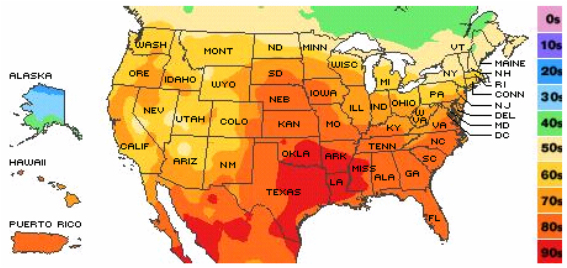

Figure 6 - USA Today Online Weather Map

Connotative associations are essential when visualizing data that conjures a mental image to the observer. The classic USA Today weather map (Figure 6) displays temperature for geographic regions by using a hypsographic map. The color ramp used for correlating color with temperature follows the guideline that observers will associate hot things with colors such as red and orange, and cold things with blue and purple. Had the color ramp been selected at random, the observer would have had to continually reference the legend. The visualization targets the goals and abilities of the intended audience by reducing the data to a quickly understandable representation.

When incorporating 3D visualizations a linear perspective projection can both add and detract from the design. When viewing a visualization that has been applied to a 3D surface, and rotated by some degree, users must be able to discern whether the volatility of fluctuations in the data decreases because of the actual data, or if in fact it is because the visual element is receding into the distance. Visual reinforcements must be used, such as grid lines or a directly correlated color mapping. Because observers function in a 3D environment, their cognitive functions are sensitive to abnormalities that violate standard depth cues [9] . Fixed-size labels that do not obey linear perspective scaling cause confusion when gauging depth. The use of transparency is also essential for reducing the effects of obscured data points in complex visualizations [3] . Linear perspective problems in 3D bar charts or collections of small multiples can be avoided by using an isometric viewpoint, but doing so also removes potential benefits that can be gained from using linear perspective, such as intuitive navigation from depth cues and the ability to view a greater proportion of the dataset.

4. Case Studies

We will now discuss the key design principles in the context of their application to actual visualization cases.

4.1 Recent Time Series Performance

A market research organization conducts weekly surveys of hundreds of participants tracking responses to many questions. Those results are tabulated, analyzed and then collected into reports typically containing up to a hundred charts. The results are presented in a flat, neutral format (Figure 7).

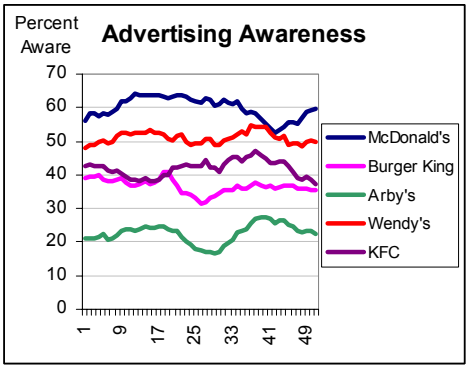

Figure 7 - 2D Line Chart

As a result, the client has all the information, easily visible without any bias to any of the many stories in the data: such as the recent dip and recovery for McDonald's, the slow decline of Burger King, the Arby's low position slowly gaining against Burger King, similar profiles for both Burger King and Arby's, etc.

What's missing is guidance to the key findings of the market researcher. At a simple level, the market researcher could simply summarize all the key findings into a table of results (Figure 8).

Chain	Awareness	3 Month Change
McDonald's	59.7	5.9%
Wendy's	49.4	-.6%
KFC	35.8	-3.5%
Burger King	34.2	-2.4%
Arby's	22.1	-4.6%

Figure 8 - Table of Findings

While a table presents key information, it lacks the immediate insight visible in the chart. Once again, perhaps a 3D representation would help? Consider the chart in Figure 9.

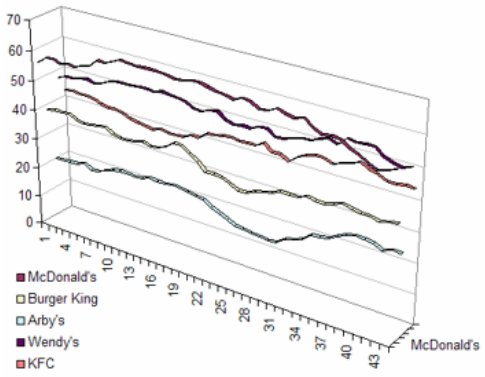

Figure 9 - Poor Use of 3D in a Line Chart

The default configuration of this ribbon chart with free-floating ribbons in 3D space makes it difficult to judge the size of the gaps and crosses between the ribbons. Increasing the gap size, adding drop lines, etc can help but introduce other issues.

Now consider instead this designed representation with even more aesthetic techniques than the previous chart:

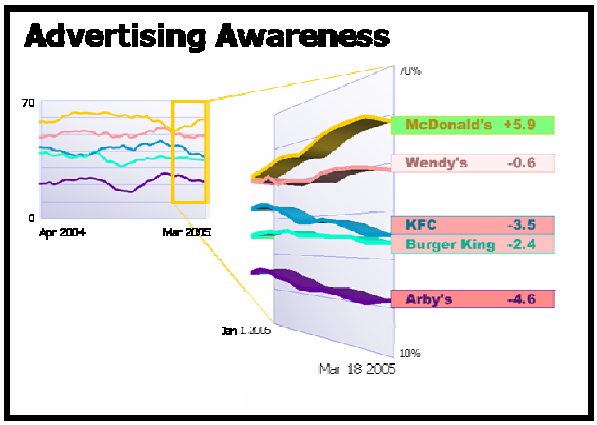

Figure 10 - Effective Use of 3D in a Line Chart

Obvious techniques include:

- Perspective viewpoint
- Ribbon lines (lines with depth)
- Highlights on ribbons and backplane
- Multiple simultaneous views
- A lot of color

Now consider these techniques in the context of the goal: guiding the viewer to the recent changes.

Perspective Viewpoint
The eye is automatically drawn to the most dynamic element in the composition: the dramatic 3D close-up view. The perspective view emphasizes the foreground over the background, increasing emphasis to the most recent performance. While perspective is highly debatable, this particular visual has carefully controlled the perspective parameters:

- *Vertical alignment*: vertical lines are not skewed potentially providing easier interpretation
- *Natural Field-of-View*: the camera is not overly wide-angle and therefore does not overly distort the perspective
- *Borders and Gridlines*: provide subtle perspective cues.

Ribbons
Ribbons are not free floating – rather they are all attached to the backplane, making direct visual comparison feasible. By using ribbons rather than just lines, the depth of the ribbon orthogonal to the back plane helps to reinforce the perceptual interpretation of the perspective.

Highlights
The highlights used in this example are not gratuitous; highlights on the backplane are brightest in the upper right corner, where the most recent performance data lies, reinforcing the goal of the communication. Highlights on the ribbons increase the illusion of the 3D perspective, potentially improving the perception of perspective. Because the image was generated using a 3D library, the lighting source for the highlights are consistent. Hand-created pseudo-3D scenes may result in inconsistent highlights, ruining the 3D effect by providing false depth cues.

Simultaneous Views
The composition of three visual elements provides context and supporting detail for the key perspective. The left 2D chart provides a broader time context, the central 3D perspective provides the focus and the rightmost text boxes provide the key findings. The left to right orientation follows the familiar left-to-right reading process of the intended audience. The initial 2D contextual view may not be necessary if the only message is recent performance, but since this image is intended to be viewed repeatedly on a weekly basis a longer time context provides continuity to the past and provides a mental cue to past views of the data.

Color
The original image is very colorful; recessive blues are used for backgrounds and brighter colors for lines. Call-outs have backgrounds color-coded based on performance that are not recessive at the extremes of performance (saturated green and red) while fading out for neutral performance, thereby attracting attention to recent performance with larger changes. The line coloring in this example was arbitrary, but could be specifically tuned to associate connotations in the viewer's mind (using brand colors, for example).

In addition to the sizzle factors, other design considerations further enhance the communication aspects of this visual:

Labels
Minimal labeling is used to reduce clutter, thereby reducing distraction away from the focus story of recent performance.

Fonts
Clean sans-serif fonts are used for labeling. Large fonts are reserved exclusively for the title and call out, thereby providing a truncated form of the key story: "Advertising Awareness (for) McDonalds (is) + 6% (over the recent time period)". Other fonts and

labels are reduced to the point where they still provide context such that the other graphics can be properly interpreted.

In this example, multiple sizzle techniques were used to make a compelling graphic. This particular design involved a separate context chart, but other alternatives could also be used to represent the context and the period of interest as they relate to the intended audience.

4.2 Intrusion Incident Explanation

Network security experts have deep expertise about the minutiae of network events. Security tools generate hundreds of thousands of records. Visual techniques for analyzing security logs can provide insight to security engineers for data analysis and also to management who need for making policy decisions at a higher level of abstraction. The goal is to have a simple depiction of intrusion events to illuminate, at a granular level, who did what to whom and when, and to see broader patterns, such as a similar patterns indicating a visual signature for certain types of attacks.

For each intrusion event, there are many data attributes associated with the intrusion data:

- Source computer (IP address) and associated port.
- Target computer (IP address) and associated port.
- Time of the event.
- Type of event.
- Protocol
- Etc.

There are also a variety of summary characteristics, such as number of attacks and number of types of attacks per each computer.

This data can be represented with a node and link representation, such as a graph. There are many different ways to represent a graph; which layout would be appropriate? A typical graph drawing approach would be to generate the graph attempting to reduce the number of crossings or attempting to reduce the distances between most frequent connections. Unfortunately, the data set is a very densely interconnected graph making most of these attempts result in graphics that appear to be a bowl of spaghetti. Instead, some aesthetic techniques were used, including animation and Gestalt principles to create a metaphor of a siege.

The company's computers are located in the center and are surrounded by attacking computers (Figure 11), similar to a medieval city encircled by attacking forces. Each attack is represented as a line from an attacker to a target. With animation, the user can scan through tens of thousands of attacks in a single minute. Visual patterns appear in the data, such as a "sweep" depicted above.

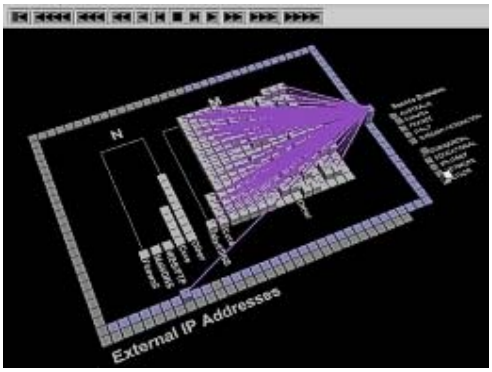

Figure 11 - Siege Metaphor for Intrusion Detection

Although this visual might be dismissed as eye-candy at first glance, it provides useful information in a form that is easy to understand:

- The "siege layout" uses gestalt grouping principles to separate attackers from targets. Encoding nodes using color or symbols are not necessary. The Gestalt phenomena of proximity and continuation are applied to the IP addresses to produce a logical grouping. Each IP address is represented by a box of the same size, but aligned and separated so that they take advantage of the observer's natural cognitive grouping skills.
- Color, bar height, line thickness, etc, is then used to represent other characteristics, such as number of attacks and attack type.
- Animation provides a means to navigate through a large data set and connotatively depicts sequence of events. Users can animate at high speed, adjust the amount of information within a frame, and step through frames.

The visual is only one part of a larger analysis and explanation visualization. There are various other interfaces as well, some of which are shown by the labeled cubes on the right side. One of the challenges when utilizing a metaphor is extending the metaphor to meet the needs of the goal: for example, how does the visualization extend to simultaneously show all attacks from one source, or how can suspected associations between attackers be represented? Sizzle must not inadvertently limit the design of the visualization such that it does not meet the requirements. Design alternatives and tradeoffs need to be managed throughout the design, development and enhancement phases of the project.

4.3 Same Effect, Different Results

Sizzle effects do not always result in more effective visualizations. The same effect used in different contexts can have very different results. The animation effect of a

"trail" has a lot of visual appeal. A trail is simply a line following the path along which a moving object has been recently. Trails can be effective in adding a temporal aspect to plotted data.

In one test case, a visualization was created with a scatter plot, depicting two key axes and a point which showed the status of the system at any given point in time. Over time, the point moved and left a trail indicating where it had previously been (Figure 12).

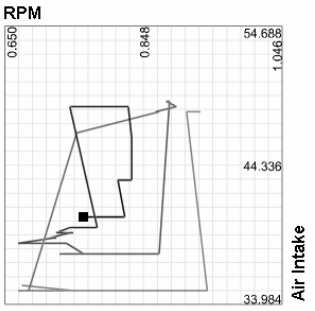

Figure 12 - 2D Trail Scatter Plot

The users were baffled by the representation and could not understand the display at all. What the users wanted and understood right away were familiar 2D line charts (Figure 13).

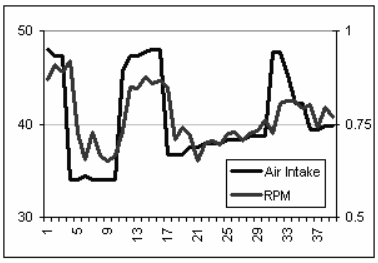

Figure 13 - 2D Trail Line Chart

However, the trail technique is successfully used in the depiction of movement over geography and through time, such as in the GeoTime visualization shown in Figure 14 [10] .

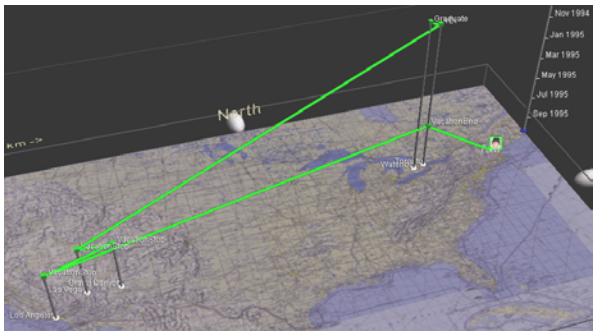

Figure 14 - 3D GeoTime Visualization

This visual clearly depicts where an object has been with the trail depicted as a line, and also with the explicit depiction of time in the third dimension. This visualization is intended for an analyst user familiar with maps and familiar with timelines; the fused representation of time and geography builds on concepts familiar to the user audience.

Clearly the context of the goal and the capabilities of the users are important considerations in the success of a visual technique. If the user's mental model cannot comprehend the target visualization, no amount of sizzle factor can succeed.

7. Conclusion

When creating a visualization for communication, the inclusion of aesthetically appealing elements can greatly increase a design's appeal, intuitiveness and memorability. Used without care, this "sizzle" can reduce the effectiveness of the visualization by obscuring the intended message. Maintaining a focus on key design principles and an understanding of the target audience can result in an effective visualization for communication. This paper has described these principles and shown their use in the creation of several effective designs.

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