Graph Design:

Visual Layering and Depth Cues

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1. Information priorities and layering

In graph design we want to show the most important information in the foreground.

Using depth cues we can layer the information in depth providing more distinctions than just foreground and background. The most important information goes in front and the least important in back

grid lines:	back
confidence interval:	middle
estimates :	front

2. Depth Cues

There are many depth cues. These depth cues include occlusion, shadow, linear perspective, detail perspective, aerial perspective, motion parallax, and binocular stereo. We will address most of these items later. Here our attention on simple plots like 2-D scatter plots. In this context the most important depth cues are occlusion and shadow.

2.1 Occlusion

Occlusion is a powerful depth cue. Things that cover (occlude) other things are in front and closer to us. Thus we plot the least important information first and progressively over plot more important information. The most important information is then on top.

Sometime in scatterplots we use the plotting order to reduce the likelihood of totally hiding points or lines. For example in bubble scatterplots (filled circles) plotting the larger bubbles first precludes the chance of their overplotting small bubbles. It may take many small bubbles to totally hide the presence of a large bubble.

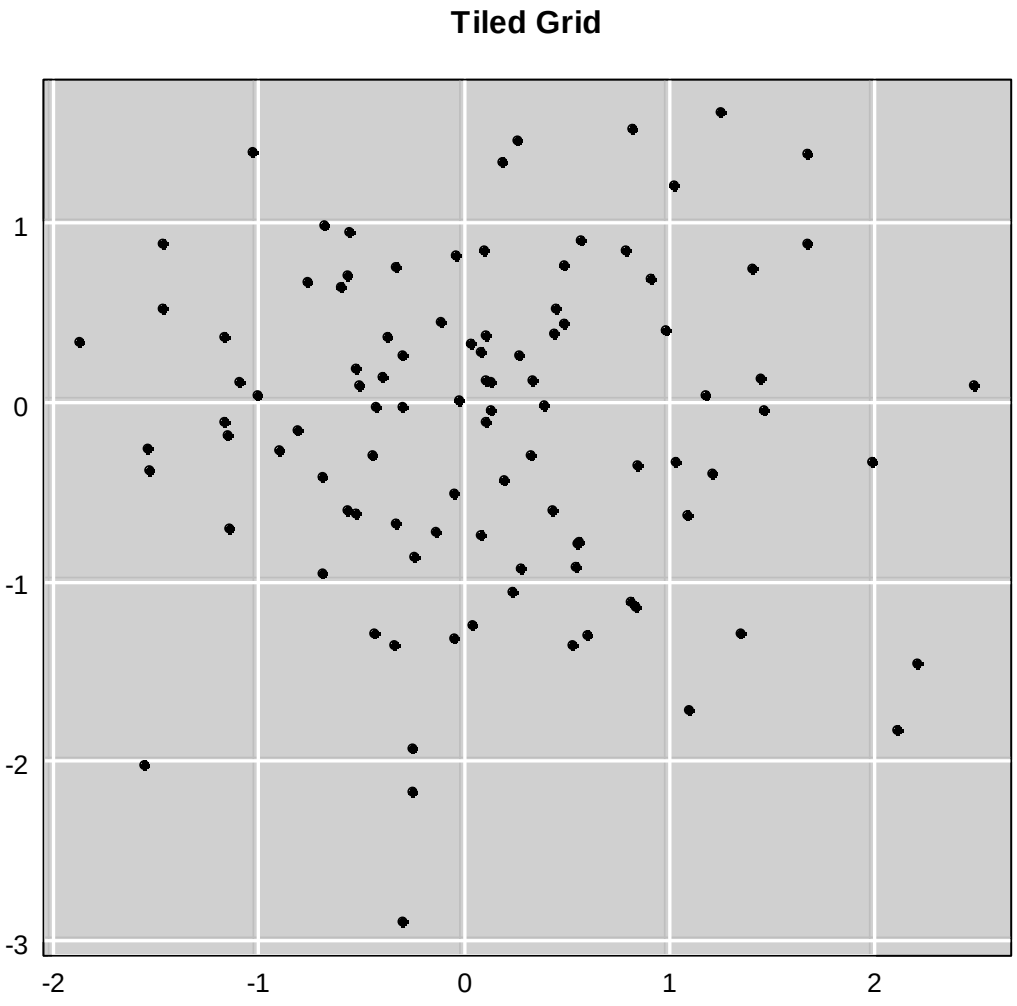
When a large bubble is important, there is a tension between putting it in front to stress its importance and putting it in back to reduce occlusion. The general recommendation here is to address occlusion. In some cases the bubble size is already shows the case's importance.

2.2 Shadows

For plotting on paper or on computer monitor, the standard assumption is that light comes from the top left and a little bit above the page or front of the monitor. The shadow of a symbol above the page surface will appear to the lower right.

Consider the shadows for a tiled surface with a light source toward the left (-x) and top (+y) the plot and above the plot surface (+z toward the viewer). The shadows will appear to the right and below a tile. That is, grooves or v-shaped troughs between tiles will have a darker side closer to the light source because that side below the surface and gets less light. Similarly grooves or troughs have lighter sides away from the light. Nothing or little is hidden from the light source. The angle of grove sides relative to a precisely position light source could be used to calculate the intensity based on Lambertian scattering from pigment. Including the position of the eye(s) would also allow calculation based on specular reflection. In practice it suffices to uses darker lines closer to the light source and lighter lines away from the light source to convey groves or troughs between

We have used white grid lines on a light gray background for our plots. We can make the plotting surface look **tiled** by shifting the grid lines slight up and to the left, and by plotting them in a darker gray before we plot the white grid lines in the original position.



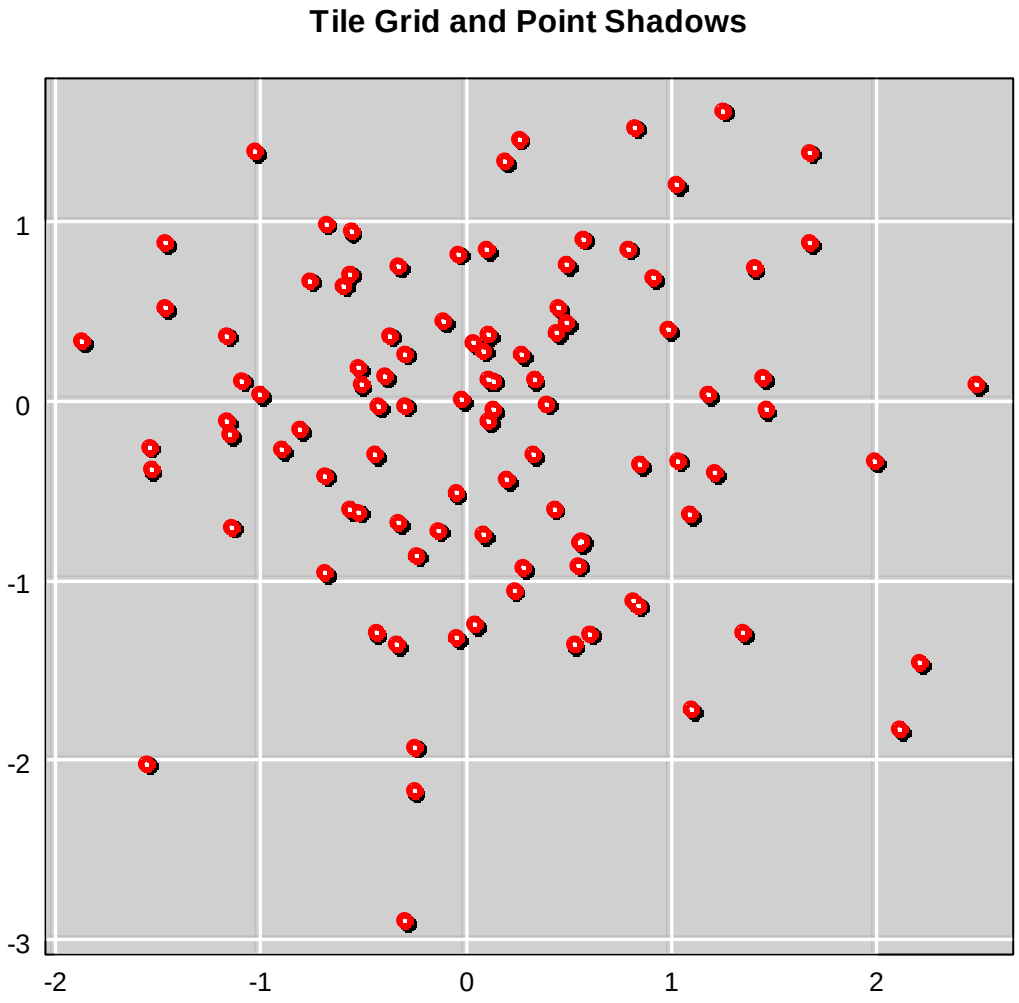
What is more important, data or grid lines? If the data is more important we make the data appear closer to the viewer than the grid lines. With a scatter plot, happenstance occlusion often works in our favor if we just plot the grid lines first. If we used a tiled surface the depth priority is clear. When showing bivariate points as filled dots we can lift the points a little off surface by plotting a shadow first. The shadows are gray dots plotted slightly to the lower right of the original dot locations.

2.3 Issues in shadow-based and lighting model depth

A tiled surface is a solid 3-D entity that can draw more attention than individual 2-D dots that may seem small, insubstantial, or even fragile by comparison. In this class it is okay to use tiled surfaces as a background. We will use low contrast tiles in an effort to reduce the risk of distracting the viewer. I suspect people will get used to tile-surface background and it will fade into the background while providing a sense of value added.

However, cognitive research might suggest there is a problem with a mismatch in dimensions.

The use of filled dots or filled dots and shadows provides a more substantial appearance. An issue is that open dots work better for partial overplotting.



Using small lighting-model rendered spheres (hemispheres since half is hidden) for dots would make them full members of a 3-D context. Since the hemisphere dots could be shown on the tile surface, the peak of the dot would provide the natural location to use in reading values.

Are dot locations read accurately against the tile grid lines? We can imagine a dot on top of a grid line. That deep point in the grove, the edge between the gray and white, may seem the natural reading location. In the construction above the center of the white

vertical line is correct reading location not the left side of a white vertical line. There probably is a small bias. If research supports this conjecture and the bias is non-negligible, a refined construction could address the issue.

If we use shadows to lift the dots off the page, do we read values against the grid using an imagined center of the dot shadow or using the center of the dot? I think that readers can assume a perspective that justifies reading the dot center rather than the dot shadow center. I sometimes put a tiny white dot in the center of a dot. This can precisely indicate the location to read.

2.4 A Suspect use of Depth

A large number of html tables separate items with ridges. The appearance of ridges can be made by shifting grid lines slightly down and to the right and plotting them in gray before plotting the grid lines at their normal location in white. (Of course other colors can be used.) The tables are structured so numbers don't plot on ridges. There is no occlusion. The ridges appear closer to the reader than the numbers. This, in my view, is the wrong priority. I conjecture that visual comparison of numbers is a little more difficult due to the intervening ridges. I would like to see experiments on this. I would also like to know if the ridges create a mind set that diminishes the likelihood that people will make comparisons.