Exercises for
Chapter 2: From Graphics to Visualization

1 EXERCISE 1

Consider the simple visualization example of plotting a graph of a two-variable scalar function $z = f(x, y)$, which is discussed in Section 2.1, Chapter 2. To depict this graph, we use a surface drawn in three dimensions (x, y, z). Now, consider that our function would have three variables, i.e. would be of the form $t = f(x, y, z)$. How would you imagine drawing the graph of this function?

2 EXERCISE 2

Consider again the example of drawing the graph of a two-variable function $z = f(x, y)$. In our discussion of this use-case in Section 2.1, Chapter 2, we assumed that we know the ranges of interest $[x_{min}, x_{max}]$ and $[y_{min}, y_{max}]$ of our two variables. Now, imagine that we do not have this information beforehand, and that both variables span the entire real-number axis $\mathbb{R}$. Imagine and describe several mechanisms that would help users in navigating the entire variable range and locate areas of interest for the function's values.

Hints: First, decide what an "area of interest" is. Next, think of automatic and/or interactive techniques that would find and highlight such areas along the variables' ranges.

3 EXERCISE 3

Consider the one-variable function $z = sin(1/x)$ where x takes values over the entire real axis $\mathbb{R}$. As x approaches zero, the graph of the function will show increasingly rapid variations between -1 and 1 or, in other words, it will describe a periodic signal with increasing frequency. Visualizing this function using the height-plot technique described in Chapter 2 will have several problems: First, it is hard to see this increase of the frequency; and second, the display will quickly become cluttered close to the point $x = 0$. Imagine and describe one or several techniques that would alleviate these two problems.

4 EXERCISE 4

Consider a two-variable function $z = f(x, y)$, where both x and y are real numbers, but z is actually a tuple, or pair, of two real values $z = (z_1, z_2)$. How would you extend or adapt the simple height plot technique described in Chapter 2 to visualize such a function? Does your proposed technique generalize easily for the case when z is a tuple of $n > 2$ real values $z = (z_1, \ldots, z_n)$? Detail your answer. In particular, discuss the upper bound of the value of n for which your proposed technique can handle the visualization problem.

5 EXERCISE 5

Consider that we have a function $z = f(x, y)$ where z is a real-value indicating the rainfall measured on a 2D terrain at locations (x, y). The measurement device that we used, however, is not very accurate at low temperatures – its accuracy is directly proportional with the temperature. To capture this information, we store, for each rainfall measurement at a location (x, y), also the temperature at that location. For this dataset, answer the following questions:

- How can we model the entire accuracy-and-rainfall dataset as a function of x and y?
- How can we visualize the rainfall over our 2D terrain, indicating, at each location, how certain we are about the accuracy of the measurement?

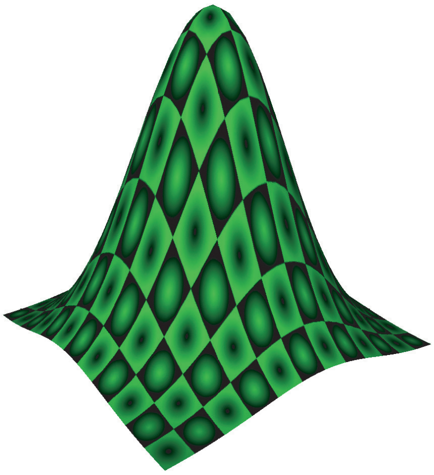
6 EXERCISE 6

Imagine a height plot of a two-variable function $z = f(x, y)$, which is visualized as a surface using the simple Phong local illumination model described in Section 2.2, Chapter 2, using a directional light source. Clearly, the result will look differently depending on the light direction. How would you propose to orient the light source with respect to the height plot so that the plot's details are optimally visible? Argue your answer with a sketch.

7 EXERCISE 7

Consider texture mapping as a graphics technique in combination with displaying a height plot of a function of two variables $z = f(x, y)$. A simple illustration is shown in Figure 2.6 (also included below). However, the example in this figure does not serve any purpose in terms of better conveying the depicted data, or depicting additional data. Imagine and describe one possible use of texturing that would bring added value to a height plot visualization.

Hints: Consider a texture whose color, luminance, or patterns would encode data-related values.



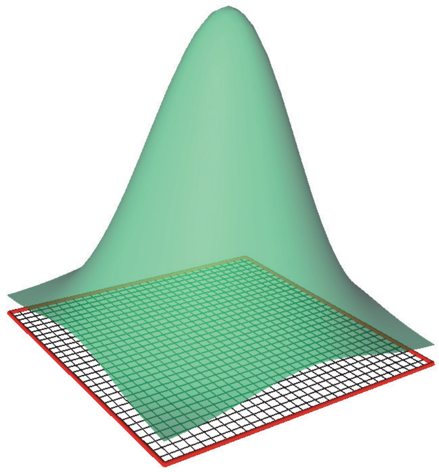
Simple texture applied on a height plot (see Chapter 2).

8 EXERCISE 8

Transparency is a useful graphics technique for letting one see several objects which normally would occlude each other at a given screen location. A simple example is shown in Figures 2.8 in Chapter 2 (also shown below). However, the indiscriminate use of transparency can also create visual artifacts that may lead to data interpretation problems in a visualization. Based on the examples in this figure, which transparency-related problems can you think of?

What would be potential solutions for these problems?

Hints: Consider what would happen if the plot had a more complex shape, and transparency would vary from point to point.



Transparent height plot (see Chapter 2).

9 EXERCISE 9

One of the last steps of the standard graphics pipeline is the so-called *viewport transform*, which maps a rectangular area A_1 on the view plane to another rectangular area A_2 on the actual screen. In general, the two rectangles A_1 and A_2 have the same aspect-ratio, so as to prevent unnatural stretching or compression of the rendered objects. Can you think of visualization applications where it would be useful to relax this equal aspect-ratio constraint?

Hints: Think of displaying objects which do not have a natural, fixed, height-to-width aspect ratio.

10 EXERCISE 10

Consider a two-variable function $z = f(x, y)$ where both x and y are real numbers, but z takes values in some non-numeric domain: For instance, think of a stock analyst that looks at the evolution of a stock portofolio, containing several stocks, over a given period of time. For each time moment x and each stock price y, the analyst gives a rating z of how overvalues or undervalued all stocks of price y were perceived at that moment x. The rating is expressed using a five-point scale: $z \in \{\text{very undervalued}, \text{undervalued}, \text{neutral}, \text{overvalued}, \text{very overvalued}\}$. Several questions follow:

- Can we express these data as a function $z = f(x, y)$? Argue your answer.
- If the previous answer is yes, can we draw this dataset using a height plot? Argue your answer and explain the differences compared to drawing a height plot of a real-valued function.
- Imagine now that, for each moment x and stock price y, the analyst picks a stock-name z that (s)he would recommend to buy for the respective (x, y) combination. The stock is represented by a text string (the stock name). Answer the previous two questions for this dataset, and outline the differences.

11 EXERCISE 11

Consider a 2D polygon grid, like the one discussed in Chapter 2 for visualizing a function of two variables as a height plot. Let us assume that our grid encodes the elevation of a terrain for a (large) map. Apart from the elevation, we also have, at each map vertex, a real-valued number that denotes the intensity of some events of interest at that map position, e.g., the amount of precipitation or local temperature. One way to draw the attention of the user to such zones would be to color the polygon vertices by some color scheme that highlights values of interest, *e.g.* using gray for low values and red for high values. However, assume this is not possible, since the grid is covered by a colored texture that represents actual geographical map details, and we do not want to affect these colors. Which other mechanisms, described in Chapter 2, could we use to attract the user's attention to such high value zones?

End of Exercises for
Chapter 2: From Graphics to Visualization