

Lab 4: An Interactive 3D Distance Calculator

This lab will give you practice in writing your own functions and in designing an interactive, menu-driven program.

Math Background

You should know what the distance between two points in the plane is: the distance between the points (x_1, y_1) and (x_2, y_2) is given by the formula

$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

When we deal with points in space, it is defined similarly. The distance between the points (x_1, y_1, z_1) and (x_2, y_2, z_2) is given by the formula

$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

This kind of distance is called *Euclidean distance*. It is not the only way to measure distance.

In Manhattan, you cannot walk on a diagonal¹. If you are at the intersection of 120th Street and Fifth Avenue and need to walk to 86th Street and First Avenue, you have to walk down $120 - 86 = 34$ blocks and across $5 - 1 = 4$ blocks, for a total of 38 blocks. (We will ignore the fact that blocks are not square.) Therefore the distance between these two corners is 38 blocks. This type of distance is sometimes called *Manhattan distance*². The Manhattan distance between the points (x_1, y_1) and (x_2, y_2) is given by the formula

$$|x_2 - x_1| + |y_2 - y_1|$$

It can be generalized to three dimensions easily.

A third way to measure distance is known as the *Chebyshev distance*³. The Chebyshev distance between the points (x_1, y_1, z_1) and (x_2, y_2, z_2) is the maximum of the distances between the x, y, and z coordinates respectively:

$$\max(|x_2 - x_1|, |y_2 - y_1|, |z_2 - z_1|)$$

Exercise

You will write a program that displays the following menu to the user:

```
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^ 3D Distance Calculator ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
[1]    Change the first point
[2]    Change the second point
[S/s]  Display the current two points
[E/e]  Calculate and display the Euclidean distance between the two points
[M/m]  Calculate and display the Manhattan distance between the two points
[C/c]  Calculate and display the Chebyshev distance between the two points
[Q/q]  Quit the program
```

¹We ignore streets like Broadway.

²It is actually based on what mathematicians call the L1 norm.

³In two dimensions it is known as *chessboard distance*.

