

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:

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

Exercise

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

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

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*.



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Enter your choice:

The characters in square brackets are what the user is supposed to type to select the menu item. The notation "[E/e]" means enter either an upper or lowercase e. Once the user presses a valid key, the program should perform the indicated action. The selections to change a point (1 and 2) should prompt the user to enter the x, y, and z coordinates of that point and not display anything else. After the action is performed, the prompt

Enter your choice:

should be redisplayed, *but not the menu*. If the user enters an invalid choice, the program should just ignore it. Points 1 and 2 should each have the initial value (0,0,0). All numbers should be printed to the screen with four digits of precision.

When you first write the program, you may use the math library's sqrt() function, but to receive full credit for this program, you must write your own sqrt() function by converting the second version of the Bakhshali program of Lab 2 into a function. Without your own sqrt() function, the program is worth at most 8 out of 10 points. There is a correct version of the Bakhshali program in the lab04 directory on the server.

Note. Your main program should use a switch statement, not nested if-statements.

What to Submit

Submit your program, however complete it is, by the end of today's lab, i.e., before the end of the class at 2:00 P.M. The instructions are just like the previous lab's:

- Create a directory in /data/biocs/b/student.accounts/cs135_sw/cs136labs/lab04/submissions whose name is your *username*. For example, I would create the directory sweiss.
- 2. Copy your program, which should be named *username_lab04.cpp*. You will lose 5% of the grade if you misname the file!
- 3. Change the permission on the directory that you created so that no one else can read or modify it. You do this with the commands
 - \$ cd /data/biocs/b/student.accounts/cs135_sw/cs136labs/lab04/submissions
 - \$ chmod 700 username

Do not submit executable files. Remember to document your code (both preamble and comments in the code) and make it easy to read. Your work will be graded based on the rubric outlined in the Programming Rules document.

There are absolutely no extensions to the deadline. You can submit a revised version of the program by 10:00 P.M. on Thursday, Sept. 20 for partial credit. If you do, you must name it with a different name than what you first posted, e.g., *username_lab04_v2.cpp*. and put it in the same directory as the original. It must be a *revision* of the original file, with only fixes to things that were not working before. I will adjust the grade based on how well the first version worked and how many changes you made.