Dynamic Programming Project (Spring 2020/2021)

Baymax

In the near future, humans will depend heavily on robots. Robots will be everywhere, they will help and serve humans obediently until some day they will realize our brittleness and revolt signaling the end of the human race (hopefully).

You own a robot, his name is Baymax (imagine a cute big rubbery white robot). Everywhere you go, Baymax goes with you. Baymax wireless module is not working, so currently you connect with him using a wired connection. Every now and then you take Baymax for a trip. Below is a description of how you both do the trip.

You mark two sequences of points, sequence A and sequence B. Sequence A has N points and Sequence B has M points. M is not necessarily equal to N. The first point in sequence A is called *a*1 and the last point is *a*n. Similarly, the first point in sequence B is *b*1 and the last point is *b*n.

In the beginning of the trip you stand at point *a1* and Baymax stands at point *b1*. Now you will move across the points in sequence A while Baymax will move across the points in sequence B. Not necessarily in the same speed. The final goal is for you to reach point *an* after going over all the points in sequence A and Bayman goal is to reach point *bn* after going over all the points in sequence B. While moving through the points in a sequence you cannot skip any point. Also, once you move to a point you cannot go back to the point before it. This applies to you and Baymax. Note that while you and Bayman visit the points together (each on his sequence) you are connected by the wire which cannot be cut.

At each step in the trip, if you are at *a*i and Bayman at *b*j then you can have the following 3 options:

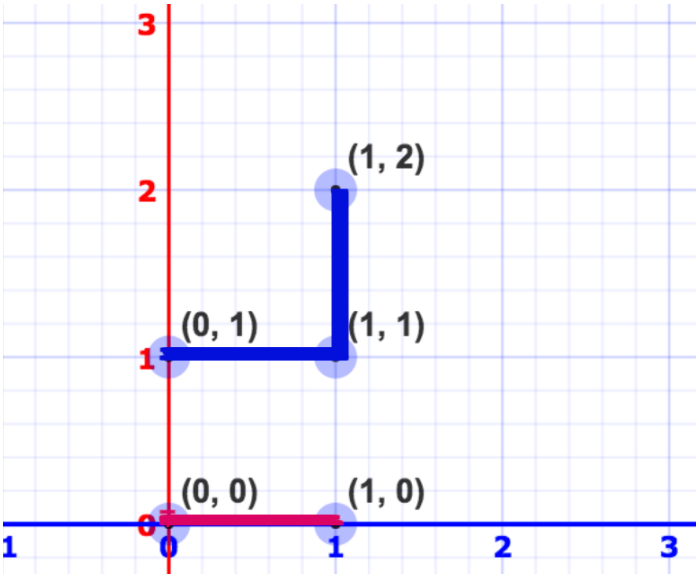
(A) You move to point ai+1 and Baymax stays at *b*j, or

(B) Baymax moves to point *b*j+1, and you stay at point *a*i, or

(C) You move to point *a*i+1 at the same time Baymax moves to point bj+1.

Your task is to figure out what is the minimum possible wire length to use that would allow you and Baymax to reach your destination. Note that they don't have to reach their destination in the fastest way nor in the least number of steps.

Let's take the following example. Given sequence A (colored in blue) which has the points (0,1), (1,1) and (1,2). And sequence B (colored in red) which has the points: (0,0) and (1,0). And given 3 wires of lengths, 1, 2 and 3. What is the minimum wire length that would allow both you and Baymax to reach your last point on each sequence?



One way to solve this question is the brute-force way, that is, try all the possible scenarios and take the least wire length that worked in any scenario. Let us examine the following two possible scenarios:

1) In Step one you start at (0,1) and Baymax at (0,0). In step two, you will move to (1,1) and Baymax moves to (1,0) at the same time. In step 3, you move to (1,2) (of course Baymax will not move since he reached his final destination.
   If we ask ourselves which of the 3 wires would allow this trip? The answer is the wire with length 2 and the wire with length 3. The wire with length 1 will not work since it will not allow the last step (step 3) to happen (the wire would be too short to allow this step).

2) In Step one you start at (0,1) and Baymax at (0,0). In step two, you move to (1,1) while Baymax doesn't move. In step 3, you move to (1,2) and Baymax moves to (1,0) at the same time.
   If we ask ourselves which of the 3 wires would allow this trip? The answer is the wire with length 2 and the wire with length 3. The wire with length 1 will not work since it will not allow the 2nd step and the last step (step 3) to happen (the wire would be too short to allow this step).

3) If you test all other possible scenarios you will find that only wires of length 2 and 3 would work. Now since we are asked to find the wire with the minimum length that would work, then the answer would be **2**.

Of course the above solution (brute-force) solution is very costly if the number of points is large. So we need to solve the question in a smarter way, using Dynamic programming.

The Input Format:

List of points for sequence A. Each two consecutive integers form a point

List of points for sequence B. Each two consecutive integers form a point

List L of integers, each representing the length of one wire.

The Output Format:

The length of the shortest wire in list L that would allow you and Baymax to finish your task.

The above example would be presented as follows on the hackerrank:

Input:

0,1,1,1,1,2
0,0,1,0
1,2,3

Output:

2

Here is a reminder of the outline of your solution:

Part1: Divide & Conquer

1- Define the value returned by the function *f* which we want to optimize.

2- Define the parameters which *f* depends on.

3- Draw the **recursion tree** for *f* using the values from the example above.

4- Write the recursive (divide and conquer) code to solve the question.

Part2: Dynamic Programming

5- Draw the table and determine the dependencies between the table cells.

6- Determine the direction of movement within the table.

7- Write the Dynamic programming code which fills the table(s).

8- Write the code that will print the sequence of moves that go you the solution.

You are requested to submit a report that explains each of the steps above which also includes graphs and figures to explain your solution and the rationale behind it. Also, you need to submit your working code on the hackerrank website as usual. The link will be provided on Moodle/FB Group.

Important:

To solve this task you are not allowed to copy/be inspired by any piece of code from the internet or from a colleague or from anyone or any place.

If any percentage of resemblance is found between your code and a code listed on the internet (even if the code is a solution for a different problem), it will be considered cheating.

You are only allowed to check the code of the three problems we studied at class and the last years problems I posted on Moodle.

If it has been proven that you cheated on this task (no matter how small the percentage is), you will get zero in the final exam mark.

One final hint to help you with this question: This question is very similar to one of the 3 DP examples we studied in class.

Good Luck

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