INF280: Competitive programming

Reading and solving a problem

A seven step method

These seven steps will help you find solutions:

- Reformulate / summarize
- Listing dimensions
- Finding good visual representations
- Do examples by hand and represent the solution visually
- Finding a naive algorithm
- Simplify the problem
- Change the point of view

Remember this method!

Step 1: Reformulate and summarize

After carefully reading the problem you should be able to:

- summarize the problem in one (or very few) sentences in the form of a question leaving out all numerical constraints listed in the dimensions (step 1)
- list the parameters or dimensions of the problem (step 2)

Do not hesitate to read the problem multiple times. *Usually* there are no bugs in the subjects, if you don't understand something you have probably missed something.

Reformulation

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We have a big rectangle split into many rectangles of known lengths and widths. We know the width of the big rectangle, what is its length?

Step 2: Listing all the dimensions of the problem

In a problem you are often given values in a dimension (it might be the age of a cow, the number of boxes, the number of lanes in a road, etc.).

You should list precisely all of the dimensions

And for each note the minimal/maximal values and whether the order is important.

Different types of dimensions

We can distinguish between input, output or implicit dimensions.

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Use this step to consider what types might work!

Let us consider Shattered Cake, what dimensions do you find?

Input dimensions

- $1 \leq N \leq 5 \times 10^6$
- $1 \leq W \leq 10^4$
- $1 \leq w_i, l_i \leq 10^4$

Output dimensions

- $1 \leq L \leq 10^4$

Implicit dimensions

- $1 \leq A \leq 10^8$

Let us consider Barrel, what are the dimensions?

Step 3: Finding good visual representations

You can now find a visual representation. Usually there is a pair of dimensions that offer a good representation...

Barrel example

Step 4: Craft examples and solve them by hand

Solving examples by hand has many benefits:

- it provides you with examples to test your program
- your mind is lazy and might find an "algorithm" if you create examples that are complex enough
- you can use your examples with the visual representation to understand some properties of the problem

Step 5: Finding a possibly naive solution

Do you have any algorithm that finds the solution regardless of the time and memory constraints?

You can try to put all the dimensions in the input.

Step 6: Simplifying the problem (dim-DSR)

You can use the list of dimensions to simplify the problem. For each dimension you can try to:

Delete (D)

What happens if remove completely the dimension?

Point in the 2D plane are now points on a 1D line

Set (S)

What happens if set all values in the dimension to a specific value?

All cows are 1 year old

Reduce (R)

What happens if we restrain the amount of possible values?

x is 0 or 1 instead of 0 to 100

Step 6: Simplifying the problem (rules)

If the problem contains constraints that the solution has to follow what happens if you simplify or remove the constraints?

This is a less mechanical way to solve problems...

...but it sometimes makes sense

Step 6 bis: Ranking simplifications

Useless simplifications

Some simplifications simplify the problem too much or lead to a problem that does not really make sense.

Promising simplification

A good simplification keeps the idea of the original problem. If a simplification is just a particular case of the original problem, it makes sense to (temporarily) forget about the original problem and trying to solve this simplification.

Beware: some “simplifications” actually make it harder to find the solution!

Ranking simplifications

Once you have listed all the simplifications you can think of, rank them from most promising to most useless.

Step 6 ter: Using simplifications

Once you have solved a simplified version of the problem you can try to generalize it by:

- using it on the original problem (or a small modification of it)
- using it to solve a part of the problem
- repeating the solution for each possible value
- if two dimensions play the same role you can try applying the simplification in one dimension and then the other
- generalizing the idea that lead to this solution

It is also often a good idea to look at what happens visually in your solution to the simplified version.

Step 7: Adopting a different approach

Usually most problems are disguised but can be solved with a standard algorithm. Instead of trying to find the algorithm for a problem you can list all the classical algorithms and try to use them to solve the algorithm...