Freshmen Programming Contest 2022

Solutions presentation

May 12, 2022

A: Avant-garde

Problem Author: Jeroen Op de Beek

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  - Define the function $f(x) =$ Highest y coordinate of any circle at this x. Calculate the integral of $f(x)$ numerically with small rectangles.

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  - Use too low resolution for your approximation technique, by setting the stepsize too big or not sampling enough random points.
  - Only sample points between -10 and 10 is not enough, circles also have a radius of at most 10.
  - Spending too much time on debugging a solution which tries to compute the area with exact formulas.

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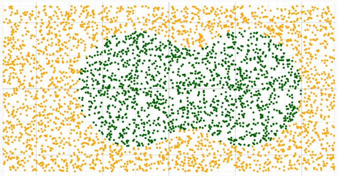

Figure 1: Monte Carlo random sampling

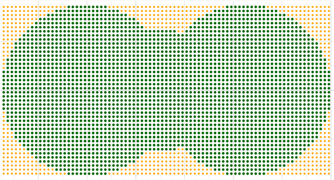

Figure 2: Pixellation based approximation

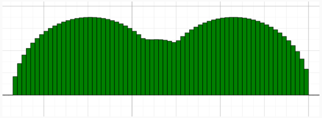

Figure 3: Approximation by numerically integrating a function
(Have to multiply the area by two at the end)

Statistics: 58 submissions, 10 accepted, 35 unknown

B: Balance by Elimination

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- This is the deepest leaf in the subtree of the deepest unbalanced node.
- Now we only need to do two DFS's: A DFS for finding the candidate leaf, and a DFS for checking if the tree became balanced. $\mathcal{O}(n)$
- **Pitfall:** Checking the globally deepest leaf, instead of the deepest leaf in the correct subtree.

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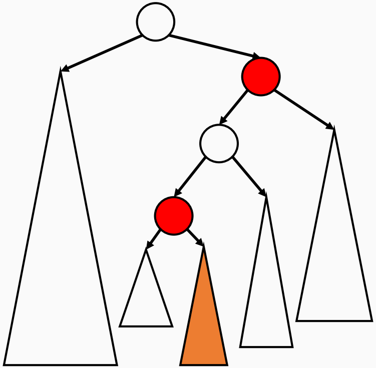

Figure 4: Proof by picture: The only candidate leaf is the leaf underneath the deepest unbalanced node.

Statistics: 32 submissions, 6 accepted, 19 unknown

C: Cake Promise

Problem Author: Maarten Sijm

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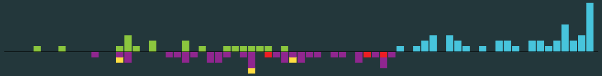
Statistics: 67 submissions, 43 accepted, 8 unknown

D: Dale ‘n’ Chip

Problem Author: Jeroen Op de Beek and Dragos-Paul Vecerdea



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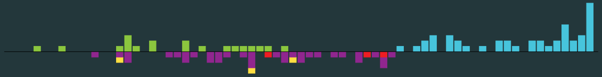

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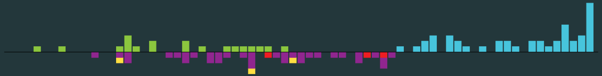

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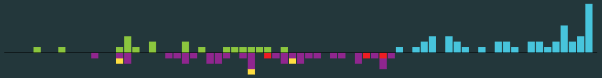

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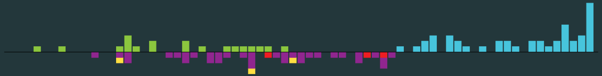

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  - Computation: $\mathit{freq}(\mathtt{R})[1, i] = \mathit{freq}(\mathtt{R})[1, i-1] + ($ 1 if ith move is “`Rock`”, 0 otherwise $)$.
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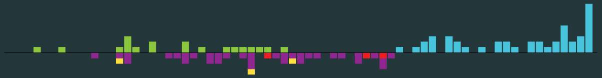

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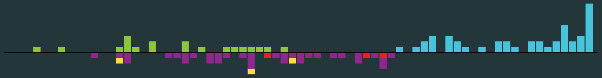

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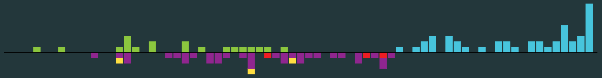

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Statistics: 104 submissions, 19 accepted, 45 unknown

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- **Problem:** Given a series of numbers and k cuts allowed, choose where to cut the list such that the sum of the largest interval (S) is the smallest.

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- **First step:** Transform the initial input into a list of numbers which represent groups of song fragments that can *not* be divided. Each song fragment is a part between two local minima.

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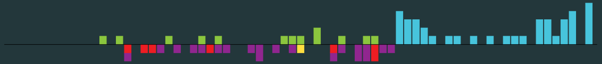
F: Fastest Thing Alive

Problem Author: Angel Karchev

- **Problem:** Find a path with no spikes, while moving up to one lane to the side for each row.

F: Fastest Thing Alive

Problem Author: Angel Karchev



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- **Solution:** Traverse every possible path until a spike is reached by using DFS.

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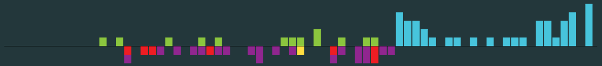

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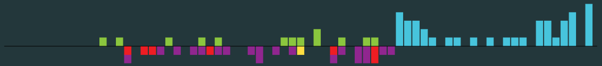

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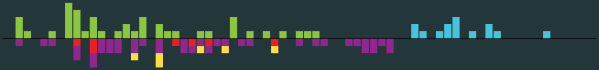
Statistics: 80 submissions, 13 accepted, 39 unknown

G: Glass Reflection

Problem Author: Maarten Sijm and Robert van Dijk



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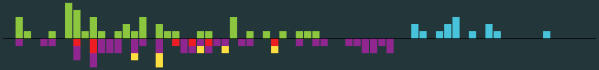

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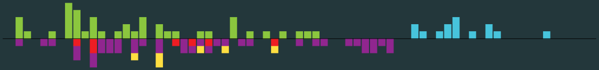

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  - When using Java, do not print letter-by-letter, because I/O is slow

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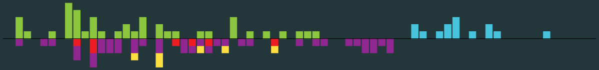

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Statistics: 107 submissions, 41 accepted, 14 unknown

H: Highways of the Future

Problem Author: Cristian-Alexandru Botocan

Problem:

- Given a directed graph, how many directed edges should you add to get one big Strongly Connected Component?

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Solution:

- Firstly we have to compute the number the number of Strongly Connected Components (SCC) of the directed graph.
  - **Def:** A Strongly Connected Component is the portion of a directed graph in which there is a path from each vertex to another vertex.
- To determine the number of the SCCs, we can use the Kosaraju's algorithm or Tarjan's algorithm.
- If the graph consists of one single SCC, we will just output 0 and finish the program.

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Solution:

- If the graph does not consist of one single SCC, then we still have to do some operations.
- **Def:** A SCC-root has no incoming edges from a different SCC.
- **Def:** A SCC-leaf has no outgoing edges to a different SCC.
- **Note:** We can have the case where a single SCC is both SCC-root and SCC-leaf.

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Solution:

- The total number of edges which have to be added is represented by:

$$\max(\text{number of SCC-roots}, \text{number of SCC-leaves})$$

- Thus, after we computed the SCCs, we can just count the number of SCC-roots and SCC-leaves and print the maximum between those.

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- Given a directed graph, how many directed edges should you add to get one big Strongly Connected Component?

Pitfalls:

- Compute the number of connected components using simple BFS/DFS instead considering Strong Connected components using Kosaraju's/Tarjan's algorithm.
- Computing the final answer as number of SCCs $- 1$, instead of computing the maximum between the total number of SCC-roots and SCC-leaves.

Statistics: 12 submissions, 0 accepted, 12 unknown

I: Inspiring Professors

Problem Author: Jeroen Op de Beek

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  - It can be proven that if this greedy approach fails, a valid assignment does not exist.
  - After a match for professor 1 is found, repeat this procedure for professor $2, 3, \cdots, n$
  - Runtime: $\mathcal{O}(n \cdot m \cdot (n \log n + m \log m))$, too slow!

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Statistics: 2 submissions, 0 accepted, 2 unknown

J: Journey to Mastery

Problem Author: Angel Karchev

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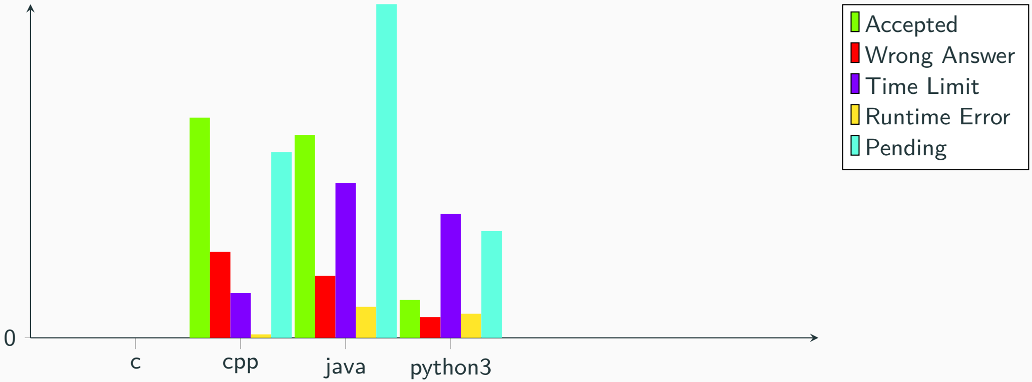
Statistics: 0 submissions, 0 accepted, 0 unknown

Language stats



Other stats

Jury work

- 371 commits (last year: 323)
- 252 secret test cases (last year: 219)
- 59 accepted jury solutions (last year: 44)
- The minimum[1] number of lines the jury needed to solve all problems is

  $$4 + 12 + 3 + 3 + 8 + 16 + 1 + 37 + 16 + 4 = 104$$

  On average 10.4 lines per problem, down from 13.9 from last year

[1] *After* codegolfing

Thanks to:

The Proofreaders

- Aleksandar Lazarov
- Arnoud van der Leer
- Davina van Meer
- Robert van Dijk
- Thomas Verwoerd

The Jury

- Angel Karchev
- Cristian-Alexandru Botocan
- Dragos-Paul Vecerdea
- Jeroen Op de Beek
- Maarten Sijm