CERC 2019

Presentation of solutions

December 3, 2019

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- The check could be done by multiple string matching algorithms.
- Examples: Hash, Z-function, Suffix Arrays, Manacher, Palindromic Trees, ...
- Complexity depends on chosen algorithm: $\mathcal{O}(N)$ is achievable.

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- Let Q be equal to $\lfloor N \rfloor$
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- Task: Find the number of strings of length N which do not contain any of given strings as a substring.

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- Observation: It can also be solved by computing the number of strings containing any of them as a substring. Then the solution is $26^N - ANS$.

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- We have to find out the way to build all such strings.
- This can be done by constructing the Aho-Corasick automaton.
- It wasn't needed to construct this automaton efficiently as there are at most $Q = 100$ characters involved (there will be $\approx Q$ states in the automaton).

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- Then we figure out approach to solve the problem, though for much lower limit of N.
- We will use Dynamic Programming where the state configuration is combination of length of the string and the state of the automation that we're currently in.
- Time complexity of this approach is $\mathcal{O}(N \cdot Q)$.
- Too slow to fit the constraints of the problem $\cdots$.

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- Finally we need to optimize DP approach to fit in the time limit.
- We will do so by using Matrix Exponentiation.
- Similarly to the DP approach we will create the transition matrix and use its N-th power to compute the answer.
- Time complexity of this approach is $\mathcal{O}(L^3 \log N)$.

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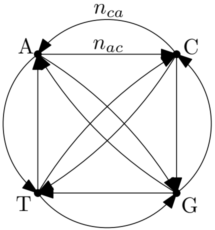
- Reformulation:
  - Directed graph on 4 vertices, edges with multiplicities.



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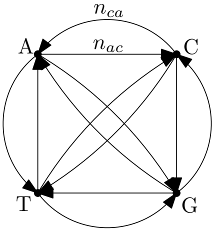
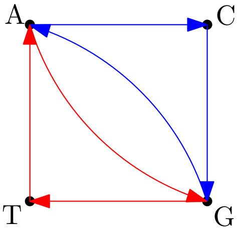


  - Decompose the graph into maximum possible number of cycles.
- Greedily start with 2-cycles, then 3-cycles and cover the rest with 4-cycles.
- Complexity is $\mathcal{O}(N)$.

Ponk Warshall 2-cycles

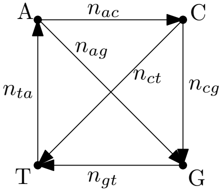
- Assume the 2-cycle is covered differently.



- Then we can change the covering without decreasing the number of cycles.

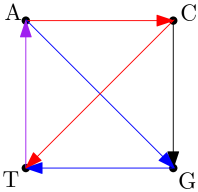
Ponk Warshall 3-cycles

- After covering 2-cycles, only one case remains



(up to isomorphism)

- Only two directed 3-cycles (with one shared edge).



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- This means we can greedily iterate from most significant bits and check, whether there are at least K of them in numbers we have:
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- NOTE: It can be proven that it is always possible to find such move.

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- NOTE: It can be proven that it is always possible to find such move.
- Complexity is $\mathcal{O}(N)$ (as the game could consist of $\mathcal{O}(N)$ moves.

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- To build the graph we have to consider two cases:
  1. For each query of size M greater than $\sqrt{N}$, go through all edges and check, whether they are in the given set.
     # of checked edges: $\frac{N}{M}N < \frac{N}{\sqrt{N}}N < N\sqrt{N}$
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- The checking step can be done (for example) with $\mathcal{O}(\log N)$ overhead if we use some standard set implementation.

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Screamers in the Storm [by Emerald Sun]

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