

## Arrays, Strings & Linked Lists Lecture 3

Wednesday, 24 July 2024

6:02 AM

### Strings

#### Sliding window algorithm

Problem:- Given a text  $T$  and pattern  $P$ , find whether  $P$  exists in  $T$  or not. If yes print all occurrences of pattern in text.

$T$  :- abac ababa acbab a  
0 4 6 12

0, 4, 6, 12

$P$  :- aba

$|T|=n$     abac ababa acbab a    (i, j)  
 $|P|=m$     aba    j)

Match every substring of size  $m$  in  $T$  with  $P$ .

# such substrings to match =  $\frac{n-m+1}{1}$

Time to match one pair of strings =  $m$

Time complexity =  $O(nm - m^2 + m) \approx O(nm)$

<https://leetcode.com/problems/find-the-index-of-the-first-occurrence-in-a-string/>

0 1 2 3 4 5 6 7 8 9 10  
a b s a d b n t s a d  
                                  i

$|T| = 11$

$|P| = 3$

$i \leftarrow \textcircled{8}$

sad

$i \leq |T| - |P|$

```
class Solution {
public:
    int strStr(string haystack, string needle) {
        if(needle.length() > haystack.length()) return -1;
        int j;
        for(int i=0; i<=haystack.length()-needle.length(); i++) {
            for(j=0; j<needle.length(); j++) {
                if(needle[j] != haystack[i+j])
                    break;
            }
            if(j==needle.length()) return i;
        }
        return -1;
    }
};
```

$\rightarrow (i+j) \% n$

```
};
```

<https://leetcode.com/problems/rotate-string/>

$s =$  abcde  
bcdea  
cdeab ✓  
deabc  
eabcd

goal = cdeab ✓

$s =$  abcdeabcde

goal = cdeab

$s = s + s$

abcdeabcde

$\rightarrow (i+j) \% n$

$s =$  a b c d e  
i j j j j  
c d e a b  
j j j j

```
class Solution:
    def rotateString(self, s: str, g: str) -> bool:
        if len(s) != len(g):
            return False
        n = len(s)
        for i in range(n):
            flag = True
            for j in range(n):
                if s[(i+j)%n] != g[j]:
                    flag = False
                    break
            if flag:
                return True
        return False
```

```

class Solution:
    def rotateString(self, s: str, g: str) -> bool:
        if len(s) != len(g):
            return False
        return goal in s+s

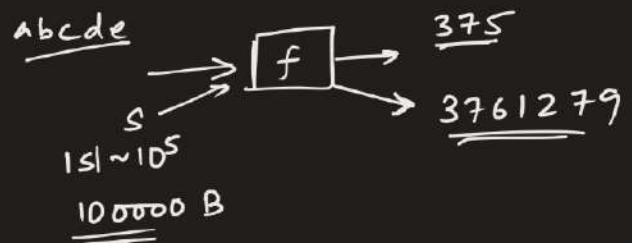
```

## Hashing of Strings

### \* Polynomial Hashing \*

$$\begin{array}{c}
 \underline{s_1} = \underline{s_2} \\
 |s_1| \quad |s_2| \\
 \sim 10^5 \quad \sim 10^5 \\
 \\
 \text{int} \quad \quad \text{int} \\
 h(s_1) = h(s_2) \\
 \underbrace{\hspace{1cm}}_{O(1)}
 \end{array}$$

$$\begin{array}{c}
 O(n \cdot m) \\
 \downarrow \\
 O(n)
 \end{array}$$



$$\begin{array}{c}
 \underline{26} \quad \underline{26} \quad \underline{26} \quad \dots \quad \underline{n-m+1} \\
 \checkmark [\underline{h_1} \quad \underline{h_2} \quad \dots]
 \end{array}$$

$$n \leftarrow |text| = \underline{\hspace{2cm}}$$

$$m \leftarrow |pattern| = \underline{\hspace{1cm}}$$

$\checkmark \underline{h_p}$

Polynomial Hash:-  $\text{hash}(s) = (s[0] + s[1] \cdot p + s[2] \cdot p^2 + s[3] \cdot p^3 + \dots) \bmod m$

$$= \left( \sum_{i=0}^{n-1} \underline{s[i]} \cdot \underline{p^i} \right) \bmod m$$

eg.

<u>s</u>	<u>h(s)</u>
<u>a</u>	1
b	2
c	3
d	4 ←
⋮	⋮
z	26
aa	32
ab	63
⋮	⋮
zz	832
aaa	993
⋮	⋮
<u>tjpabc</u> ...	<span style="border: 1px solid black; padding: 2px;">  </span>

p=31

$10^9+7+1$   
→ ①

'a' = 1  
 'b' = 2  
 'c' = 3  
 ⋮  
 'z' = 26

$s[i] - 'a' + 1$

$1 + 2 \times 31$

$1 + 1 \times 31 + 1 \times (31)^2$

Problem:-

Search duplicate strings in an array of strings.  
Given a list of strings  $s_i$ ,  $1 \leq i \leq n$ , each no longer than  $m$  characters, find all the unique strings.

$$\begin{matrix} 0 & 1 & 2 & & n-1 \\ [s_1, & s_2, & s_3, & \dots, & s_n] \end{matrix}$$

$|s_i| \leq m$

$O(n^2)$  comparisons

$T \equiv O(n^2 \cdot m)$  ✓

Sorting-  
 $O(n \log n)$

$O(nm \log n)$  ✓  
 $10^6 \times \log 10^4 \sim 10^8$

for strings

using hashing:-

$2 \leftarrow \{ \text{hashing} \}$

$> < =$   
 $O(m)$

Using hashing:-

② ←  
{hashing.}

- > Precomputed PP(m)  $\leftarrow O(m)$
- > hash value of all strings  $\leftarrow O(nm)$
- > Sort the hash values & compare adjacent values  $\rightarrow O(n \log n)$

$$10^6 + 10^4 \times 10^4 \sim 10^6$$

$$O(nm + n \log n)$$

$$n \sim 10^4$$

$$m \sim 10^2$$