AOA EXPERIMENT 13

Name: Mohammed Arhaan Ali
Div: S11
Roll No: 02

Aim: To study and implement the Rabin-Karp Algorithm for Pattern Searching.

Theory:
Given a text T[0. . .n-1] and a pattern P[0. . .m-1], write a function search(char P[], char T[]) that prints all occurrences of P[] present in T[] using the Rabin Karp algorithm. You may assume that n > m.
Examples:
Input: T[] = “THIS IS A TEST TEXT”, P[] = “TEST”
Output: Pattern found at index 10
Input: T[] = “AABAACAADAABAABA”, P[] = “AABA”
Output: Pattern found at index 0
Pattern found at index 9
Pattern found at index 12

Rabin-Karp Algorithm:

In the Naive String Matching algorithm, we check whether every substring of the text of the pattern’s size is equal to the pattern or not one by one.
Like the Naive Algorithm, the Rabin-Karp algorithm also checks every substring. But unlike the Naive algorithm, the Rabin Karp algorithm matches the hash value of the pattern with the hash value of the current substring of text, and if the hash values match then only it starts matching individual characters. So the Rabin Karp algorithm needs to calculate hash values for the following strings.

- Pattern itself
- All the substrings of the text of length m which is the size of the pattern.

How is Hash Value calculated in Rabin-Karp?

Hash value is used to efficiently check for potential matches between a pattern and substrings of a larger text. The hash value is calculated using a rolling hash function, which allows you to update the hash value for a new substring by efficiently removing the contribution of the old character and adding the contribution of the new character. This makes it possible to slide the pattern over the text and calculate the hash value for each substring without recalculating the entire hash from scratch. Here's how the hash value is typically calculated in Rabin-Karp:

Step 1: Choose a suitable base and a modulus:

- Select a prime number 'p' as the modulus. This choice helps avoid overflow issues and ensures a good distribution of hash values.
- Choose a base 'b' (usually a prime number as well), which is often the size of the character set (e.g., 256 for ASCII characters).

Step 2: Initialize the hash value:

- Set an initial hash value 'hash' to 0.

Step 3: Calculate the initial hash value for the pattern:

- Iterate over each character in the pattern from left to right.
- For each character 'c' at position 'i', calculate its contribution to the hash value as 'c * (bpattern_length – i – 1) % p' and add it to 'hash'.
- This gives you the hash value for the entire pattern.

Step 4: Slide the pattern over the text:

- Start by calculating the hash value for the first substring of the text that is the same length as the pattern.

Step 5: Update the hash value for each subsequent substring:

- To slide the pattern one position to the right, you remove the contribution of the leftmost character and add the contribution of the new character on the right.
- The formula for updating the hash value when moving from position 'i' to 'i+1' is:

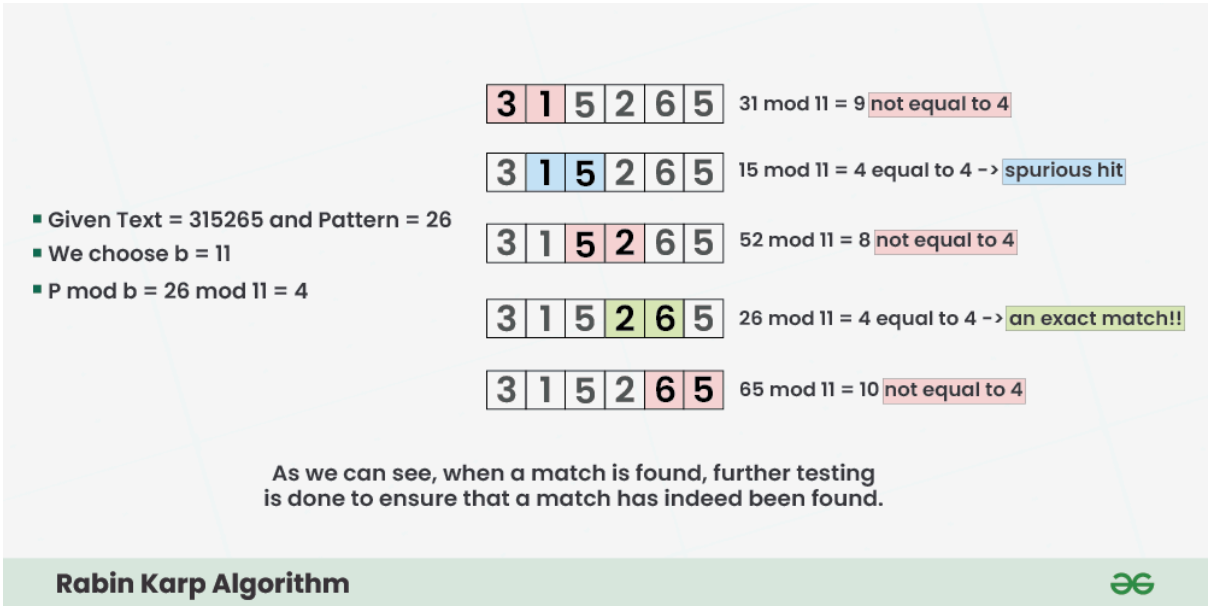
hash = (hash - (text[i - pattern_length] * (bpattern_length - 1)) % p) * b + text[i]

Step 6: Compare hash values:

- When the hash value of a substring in the text matches the hash value of the pattern, it's a potential match.

- If the hash values match, we should perform a character-by-character comparison to confirm the match, as hash collisions can occur.

Below is the Illustration of above algorithm:



Step-by-step approach:

- Initially calculate the hash value of the pattern.
- Start iterating from the starting of the string:
  - Calculate the hash value of the current substring having length m.
  - If the hash value of the current substring and the pattern are the same check if the substring is the same as the pattern.
  - If they are the same, store the starting index as a valid answer. Otherwise, continue for the next substrings.
- Return the starting indices as the required answer.

Program:

```
#include <stdio.h>
#include <string.h>

// d is the number of characters in the input alphabet
#define d 256

/* pat -> pattern
    txt -> text
    q -> A prime number
```

```
*/
void search(char pat[], char txt[], int q)
{
    int M = strlen(pat);
    int N = strlen(txt);
    int i, j;
    int p = 0; // hash value for pattern
    int t = 0; // hash value for txt
    int h = 1;

    // The value of h would be "pow(d, M-1)%q"
    for (i = 0; i < M - 1; i++)
        h = (h * d) % q;

    // Calculate the hash value of pattern and first
    // window of text
    for (i = 0; i < M; i++) {
        p = (d * p + pat[i]) % q;
        t = (d * t + txt[i]) % q;
    }

    // Slide the pattern over text one by one
    for (i = 0; i <= N - M; i++) {

        // Check the hash values of current window of text
        // and pattern. If the hash values match then only
        // check for characters one by one
        if (p == t) {
            /* Check for characters one by one */
            for (j = 0; j < M; j++) {
                if (txt[i + j] != pat[j])
                    break;
            }

            // if p == t and pat[0...M-1] = txt[i, i+1,
            // ...i+M-1]
            if (j == M)
```

```
            printf("Pattern found at index %d \n", i);
        }

        // Calculate hash value for next window of text:
        // Remove leading digit, add trailing digit
        if (i < N - M) {
            t = (d * (t - txt[i] * h) + txt[i + M]) % q;

            // We might get negative value of t, converting
            // it to positive
            if (t < 0)
                t = (t + q);
        }
    }
}

/* Driver Code */
int main()
{
    char txt[] = "ANALYSISOFALGORITHM";
    char pat[] = "ALGO";

    // A prime number
    int q = 101;
    printf("The text is given by: ANALYSISOFALGORITHM\n");
    printf("The pattern is given by: ALGO\n");

    // function call
    search(pat, txt, q);
    return 0;
}
```

Output:

```
PS C:\Users\arhaa\OneDrive\Desktop\AOA> cd "c:\Users\arhaa\OneDrive
($?) { .\rabinkarp }
The text is given by: ANALYSISOFALGORITHM
The pattern is given by: ALGO
Pattern found at index 10
PS C:\Users\arhaa\OneDrive\Desktop\AOA>
```

Conclusion: Thus we have successfully implemented the Rabin-Karp String matching algorithm.