Experiment - 9

Student Name: Hemant Narain Jha **UID:** 23BCS10022
Branch: BE-CSE **Section/Group:** KRG-2B
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1. **Aim:** Develop a program and analyze complexity to find all occurrences of a pattern P in a given stringS.
2. **Objective :** Analyze to find all occurrences of a pattern P in a given string S
3. **Input/Apparatus Used:** String is taken as input in order to find pattern from it.
4. **Procedure:**

1. We will first create the LPS array.

2. Initialize two variables - „strIdx" and „patIdx" to iterate over the string and the pattern, respectively.

3. If „pat[patIdx]" equals „str[strIdx]", we will increment both the indexes.

4. When „patIdx" equals the length of the pattern, this means that the pattern is found in the string. Therefore we print the index and set „patIdx" = LPS[patIdx-1].

5. If „pat[patIdx]" is not equal to „str[strIdx]", we update the patIdx witht he last index that matches with „str[strIdx]" using the LPS array.

Doing this, we will find all occurrences of the pattern in the string.

5. Algorithm:

String manipulation/matching algorithms: Rabin Karp algorithm

Naïve brute-force algorithm:

Naïve pattern searching is the simplest method among other pattern searching algorithms. It checks for all character of the main string to the pattern. This algorithm is helpful for smaller texts. It does not need any pre-processing phases. We can find substring by checking once for the string. It also does not occupy extra space to perform the operation.

```
NAIVE-STRING-MATCHER(T, P)
1  n = T.length
2  m = P.length
3  for s = 0 to n − m
4      if P[1..m] == T[s + 1..s + m]
5          print "Pattern occurs with shift" s
```

The Rabin-Karp-Algorithm

The Rabin-Karp string matching algorithm calculates a hash value for the pattern, as well as for each M-character subsequences of text to be compared. If the hash values are unequal, the algorithm will determine the hash value for next M-character sequence. If the hash values are equal, the algorithm will analyze the pattern and the M-character sequence. In this way, there is only one comparison per text subsequence, and character matching is only required when the hash values match.

```
RABIN-KARP-MATCHER(T, P, d, q)
 1  n = T.length
 2  m = P.length
 3  h = d^(m−1) mod q
 4  p = 0
 5  t_0 = 0
 6  for i = 1 to m                    // preprocessing
 7      p = (dp + P[i]) mod q
 8      t_0 = (dt_0 + T[i]) mod q
 9  for s = 0 to n − m                // matching
10      if p == t_s
11          if P[1..m] == T[s + 1..s + m]
12              print "Pattern occurs with shift" s
13      if s < n − m
14          t_{s+1} = (d(t_s − T[s + 1]h) + T[s + m + 1]) mod q
```

Example: For string matching, working module q = 11, how many spurious hits does the Rabin-Karp matcher encounters in Text T = 31415926535.....

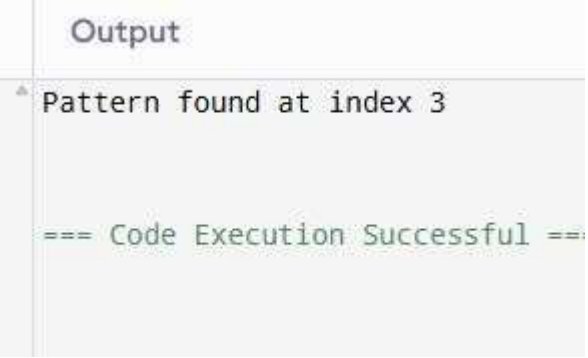
1. T = 31415926535.....
2. P = 26
3. Here T.Length =11 so Q = 11
4. And P mod Q = 26 mod 11 = 4

5. Now find the exact match of P mod Q...

6. Code and Output :

```
import java.util.*;
public class RabinKarp {
public static void rabinKarp(String text, String pattern, int q) {
int d = 256; // number of characters in the input alphabet
int n = text.length();
int m = pattern.length();
int p = 0; // hash value for pattern
int t = 0; // hash value for text
int h = 1;
// The value of h would be pow(d, m-1) % q
for (int i = 0; i < m - 1; i++)
h = (h * d) % q;
// Calculate hash value for pattern and first window of text
for (int i = 0; i < m; i++) {
p = (d * p + pattern.charAt(i)) % q;
t = (d * t + text.charAt(i)) % q;
}
// Slide the pattern over the text one by one
for (int i = 0; i <= n - m; i++) {
// If the hash values match, check for characters one by one
if (p == t) {
boolean match = true;
for (int j = 0; j < m; j++) {
if (text.charAt(i + j) != pattern.charAt(j)) {
match = false;
break;
}
}
if (match)
System.out.println("Pattern found at index " + i);
}
// Calculate hash value for next window of text
if (i < n - m) {
t = (d * (t - text.charAt(i) * h) + text.charAt(i + m)) % q;
if (t < 0)
t = (t + q);
}
```

```
}
}
public static void main(String[] args) {
String text = "ABCCDDAEFG";
String pattern = "CDD";
int q = 101; // A prime number
System.out.println("RABIN–KARP STRING MATCHING ALGORITHM\n");
rabinKarp(text, pattern, q);
}
}
```



7. Complexity:

The running time of **RABIN-KARP-MATCHER** in the worst-case scenario **O ((n-m+1) m** .