The Rabin Karp String Matching Algorithm

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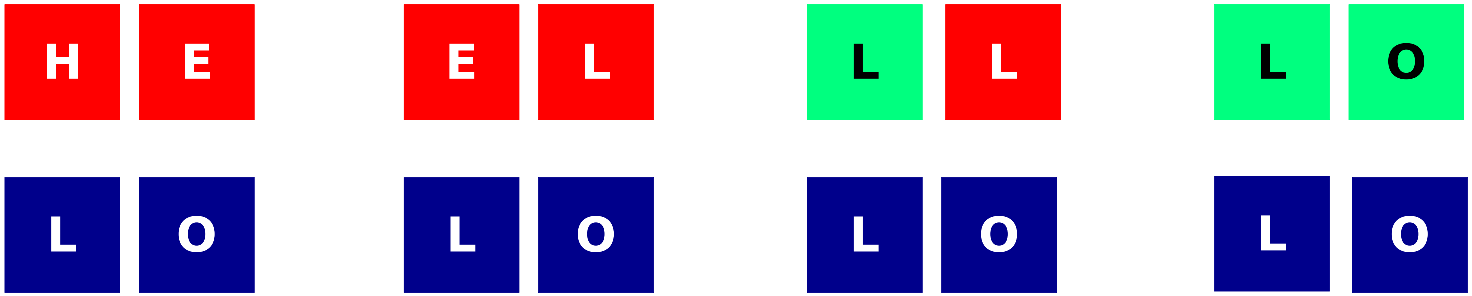
Rabin-Karp

- Also Known as Karp-Rabin algorithm
- Created by **Richard M. Karp** and **Michael O. Rabin**
- Uses **Hashing** to match patterns in text
- Where ***n*** is the length of the text to search in, and ***m*** is the length of the searched pattern:
    - Best case complexity is **O(n + m)**
    - Worst case complexity is **O(nm)**
- Often used to detect plagiarism

String Matching

Text	H	E	L	L	O	W	O	R	L	D
Pattern	L	O								



Hashed String Matching

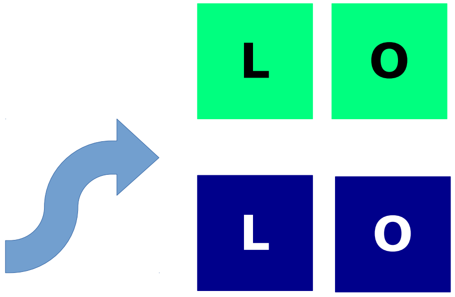
	1	2	3		4	5		6		7
	H	E	L		O	W		R		D
Text	H	E	L	L	O	W	O	R	L	D
Pattern	L	O								

$$H(s)=\sum_{i=0}^{n} char_i$$

L O

3 + 4 = 7

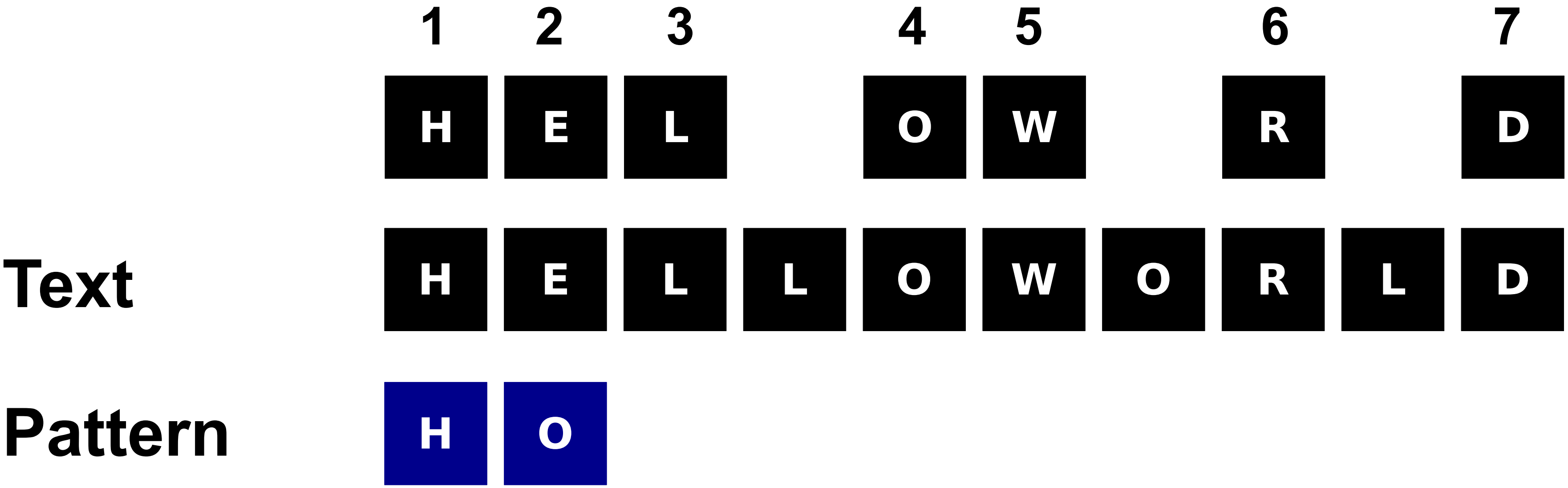
H	E	1 + 2 = 3 => $3 \neq 7$
E	L	2 + 3 = 5 => $5 \neq 7$
L	L	3 + 3 = 6 => $6 \neq 7$
L	O	3 + 4 = 7 => $7 = 7$



L O

L O

Collision

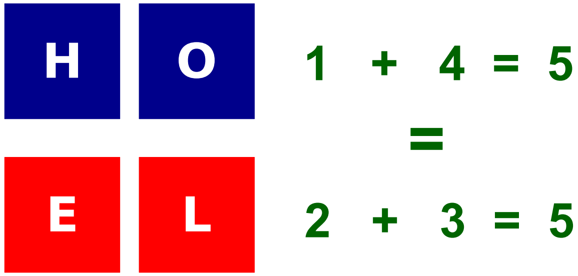


1 2 3 4 5 6 7

H E L O W R D

Text H E L L O W O R L D

Pattern H O



H O 1 + 4 = 5

=

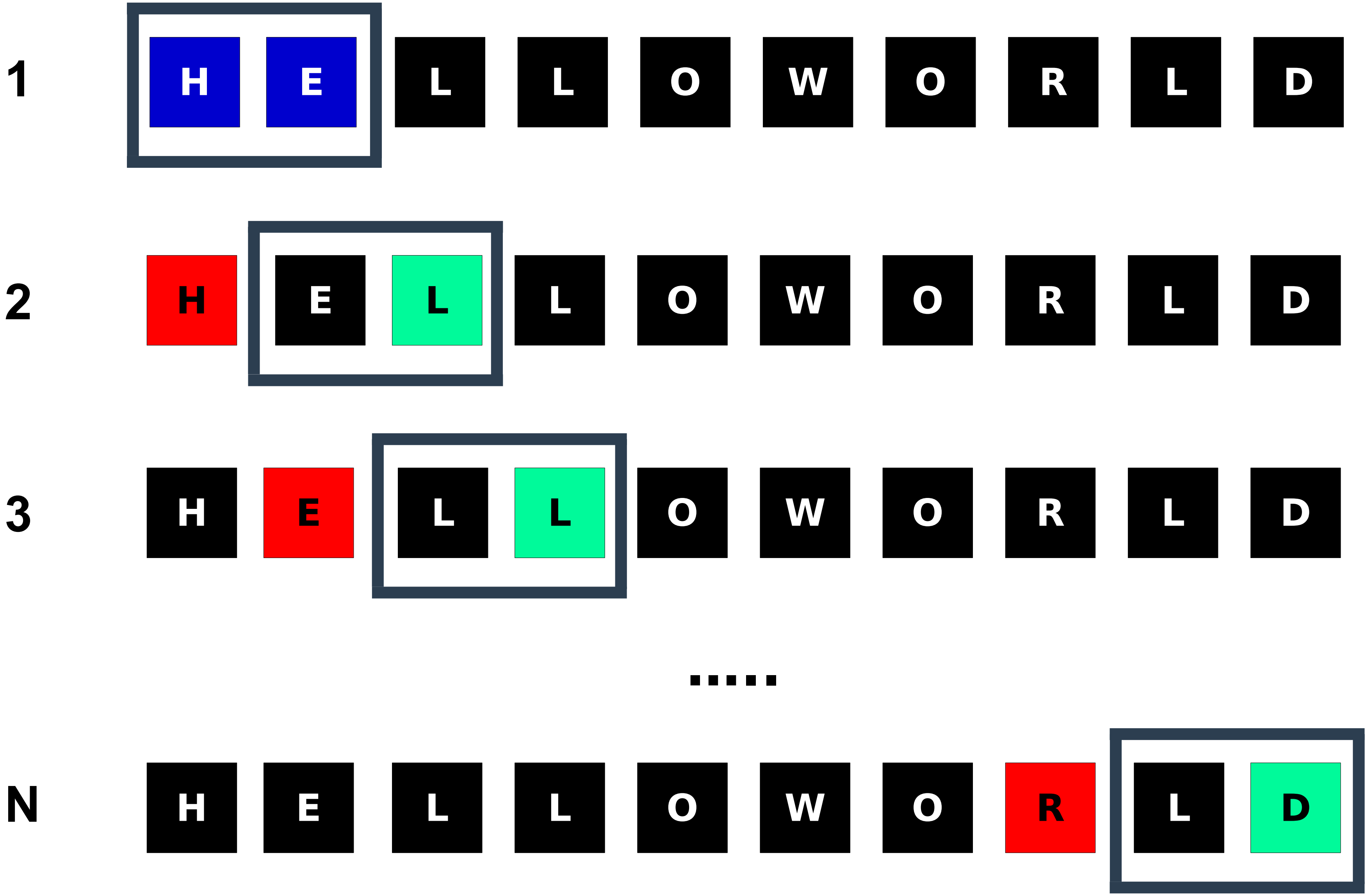
E L 2 + 3 = 5

Choosing a bad hashing function results in a high probability of a collision (finding equal hashes for different patterns)

Rolling Hash

- A function that allows calculating a new hash from an old one.
- Faster than a normal hash function.
- Usually has a polynomial or logarithmic complexity but varies from a function to another.
- Some rolling hash functions :
    - Polynomial rolling hash
    - Rabin fingerprint
- Can be used to slice content into pieces for easier processing.

Rolling Hash



1 H E L L O W O R L D

2 H E L L O W O R L D

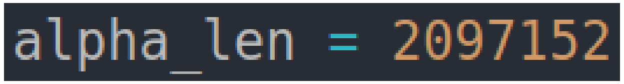
3 H E L L O W O R L D

.....

N H E L L O W O R L D

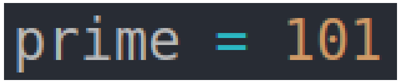
Rabin Fingerprint

1 – define your alphabet’s length



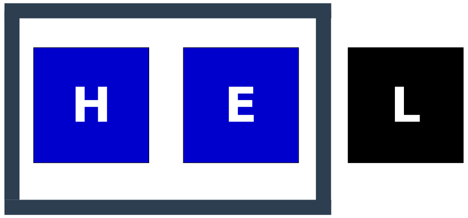
```
alpha_len = 2097152
```

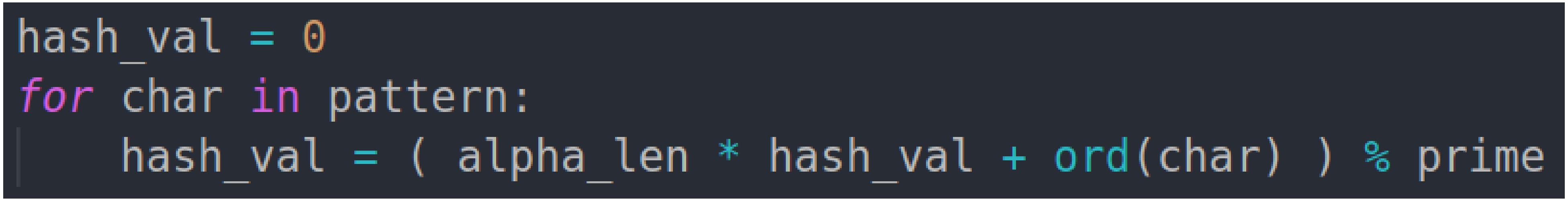
2 – choose a random prime number



```
prime = 101
```

3 – calculate initial hash window





```
hash_val = 0
for char in pattern:
    hash_val = ( alpha_len * hash_val + ord(char) ) % prime
```

let’s hash the string ‘he’ / in UTF-8 : h is 104, e is 101

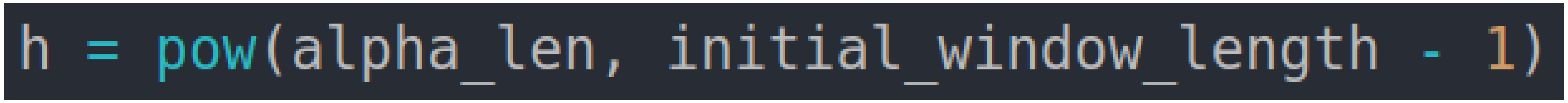
hash(‘h’) = (2097152 * 0 + 104) % 101 = 3

hash(‘he’) = (2097152 * hash(‘h’) + 101) % 101 = 65

Rabin Fingerprint

4 – calculate the H value

$$alphabet\ length^{initial\ window\ length - 1}$$



```
h = pow(alpha_len, initial_window_length - 1)
```

Examples :

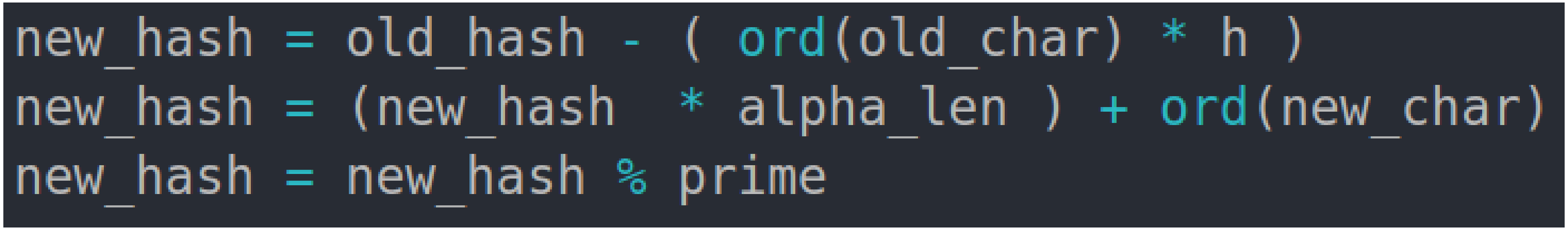
For a 3 characters window

Utf-8 $h = 2097152^{3-1} = 2097152^{2} = 4398046511104$

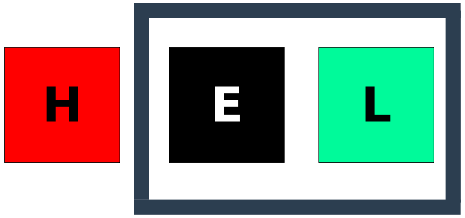
Ascii $h = 256^{3-1} = 256^{2} = 65536$

Rabin Fingerprint

5 - Loop over the rest of the string and recalculate a new hash for each new window using the hash of the previous one



```
new_hash = old_hash - ( ord(old_char) * h )
new_hash = (new_hash  * alpha_len ) + ord(new_char)
new_hash = new_hash % prime
```



let's hash the string 'el' in UTF-8 :

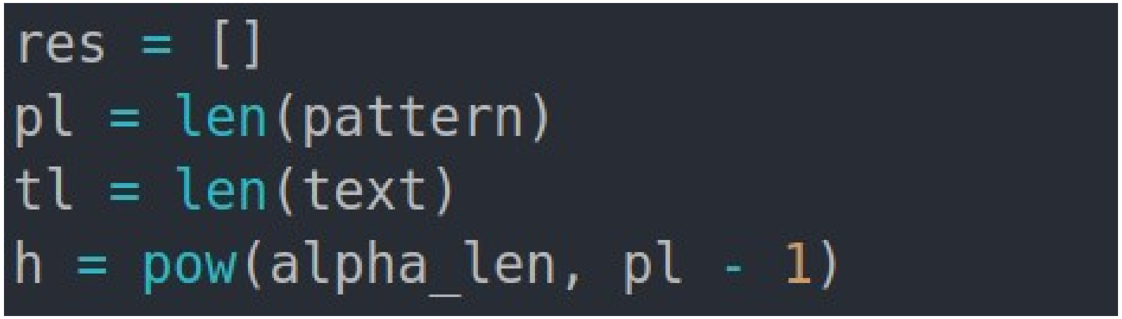
h is 104, e is 101, l is 108 / hash('he') = 65 / h =

hash('el') = [[65 - (104 * h)] * 2097152 + 108] % 101

hash('el') = 68

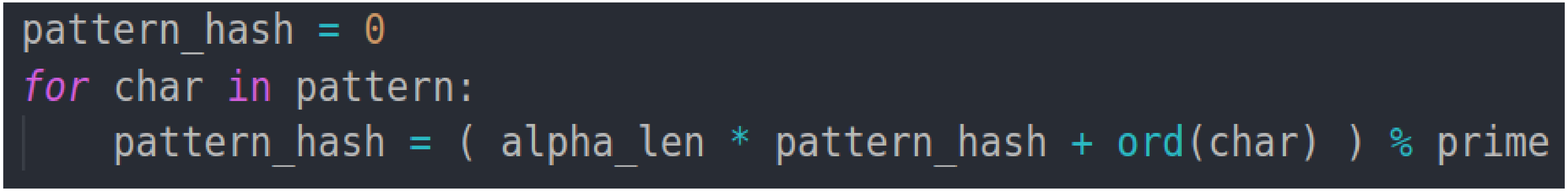
Rabin Karp String Matching

1 – initialization



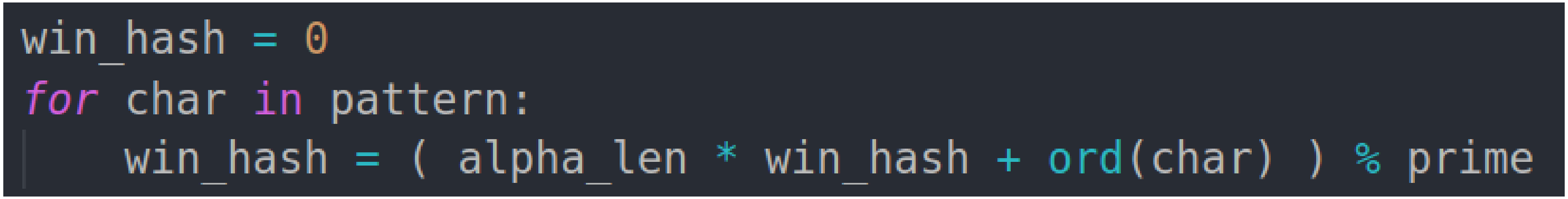
```
res = []
pl = len(pattern)
tl = len(text)
h = pow(alpha_len, pl - 1)
```

2 – hashing the searched pattern



```
pattern_hash = 0
for char in pattern:
    pattern_hash = ( alpha_len * pattern_hash + ord(char) ) % prime
```

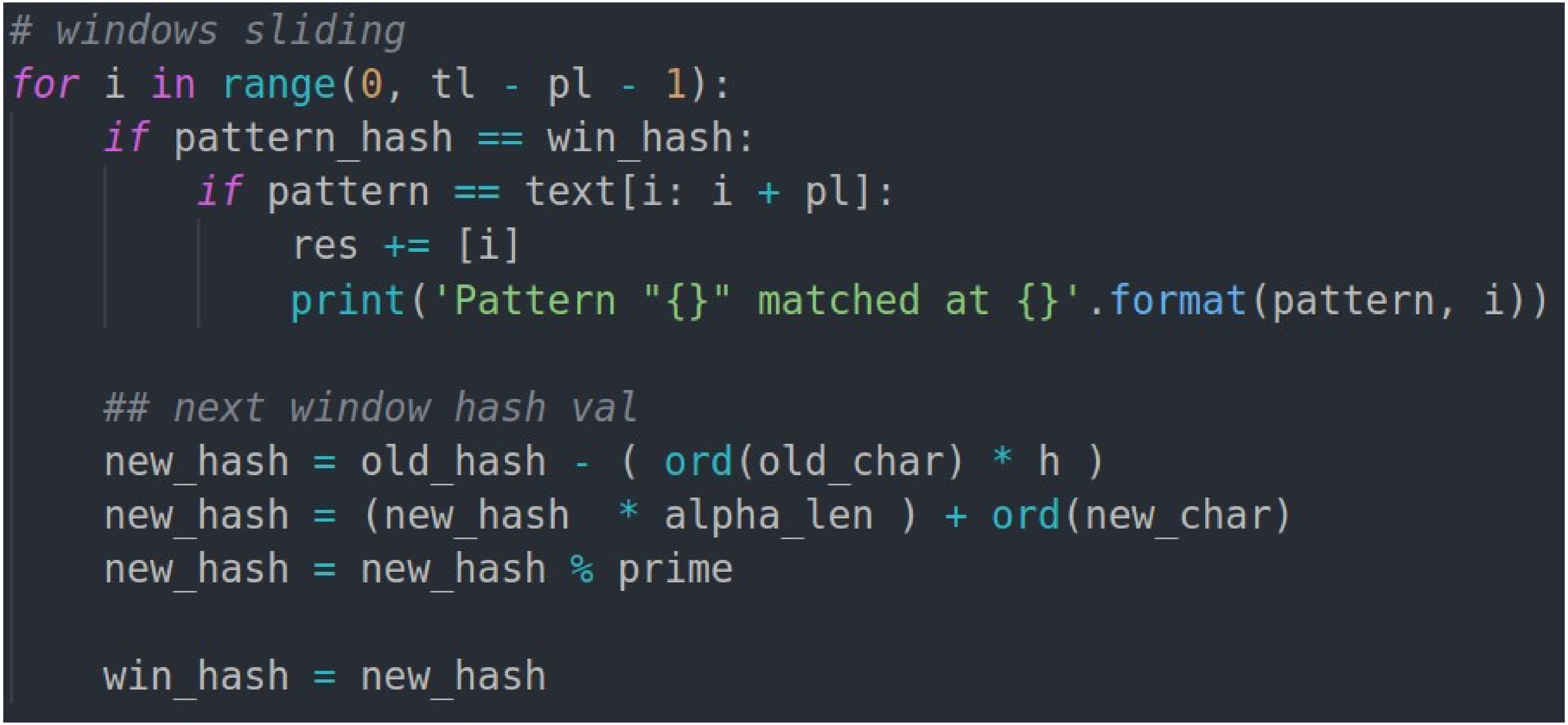
3 – hashing the first window :



```
win_hash = 0
for char in pattern:
    win_hash = ( alpha_len * win_hash + ord(char) ) % prime
```

Rabin Karp String Matching

4 – Sliding the window



```
# windows sliding
for i in range(0, tl - pl - 1):
    if pattern_hash == win_hash:
        if pattern == text[i: i + pl]:
            res += [i]
            print('Pattern "{}" matched at {}'.format(pattern, i))

    ## next window hash val
    new_hash = old_hash - ( ord(old_char) * h )
    new_hash = (new_hash  * alpha_len ) + ord(new_char)
    new_hash = new_hash % prime

    win_hash = new_hash
```

Information

Resources

brilliant.org/wiki /rabin-karp-algorithm

Rabin Karp String Search Algorithm (Book)

Code

github.com/LogX7/rabin_karp

Contact

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