IMPLEMENTATION OF TEXT EDITOR USING ROPE DATA STRUCTURE

A MAJOR PROJECT REPORT

Submitted by

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IN

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BONAFIDE CERTIFICATE

This is to certify that the major project report entitled “**IMPLEMENTATION OF STACK USING TEXT EDITOR”** submitted by

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in partial fulfilment of the requirements for the award of the **bachelor of Master of Technology** in **COMPUTER SCIENCE ENGINERRING** is a bonafide record of the work carried out under my guidance and supervision at Amrita School of Engineering, Chennai.

Signature

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This project report was evaluated by us on ……………...

INTERNAL EXAMINER EXTERNAL EXAMINER

ACKNOWLEDGEMENT:

I offer my sincere pranams at the lotus feet of Universal guru, MATA AMRITANANDAMAYI DEVI who blessed me with her grace to make this a successful project.

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1. ABSTRACT:

A Rope data structure is a tree data structure that is used to more efficiently store and manage huge strings. In comparison to a typical String, it allows operations like insertion, deletion, search, and random access to be performed considerably faster and more efficiently. This data structure, as well as its many operations and implementation, will be examined. To handle huge strings effectively, software such as text editors like Sublime, email services like Gmail, and text buffers use this data structure. In this report, we'll look at the Rope Data Structure and compare it to a conventional string to see when it's appropriate to utilise it, as well as its benefits and drawbacks. The Rope has a wide range of uses, but the most popular is in text editors that deal with vast amounts of text. We have also used Boyer Moore Algorithm for Pattern Searching which is used in find and replace button of the text editor.

2. INTRODUCTION:

A rope is a type of binary tree i.e., each node can have a maximum of 2 children at the maximum, where every leaf node holds a String or a Substring and the length of the same (Also known as the "weight" for the corresponding leaf node) and every following parent node holds the total sum of the weights of the leaf nodes in its left subtree, which in turn is described as the weight of the said node. In a simpler form, the weight of a node is the sum of all the leaf nodes that sprout from its immediate left child node.

In computer programming, a rope, also known as a cord, is a data structure made up of smaller strings that is used to store and manage a long string efficiently. A text editing tool, for example, might utilise a rope to represent the text being edited, allowing actions like insertion, deletion, and random access to be performed quickly.

The string is: Hello I am a rope data structure

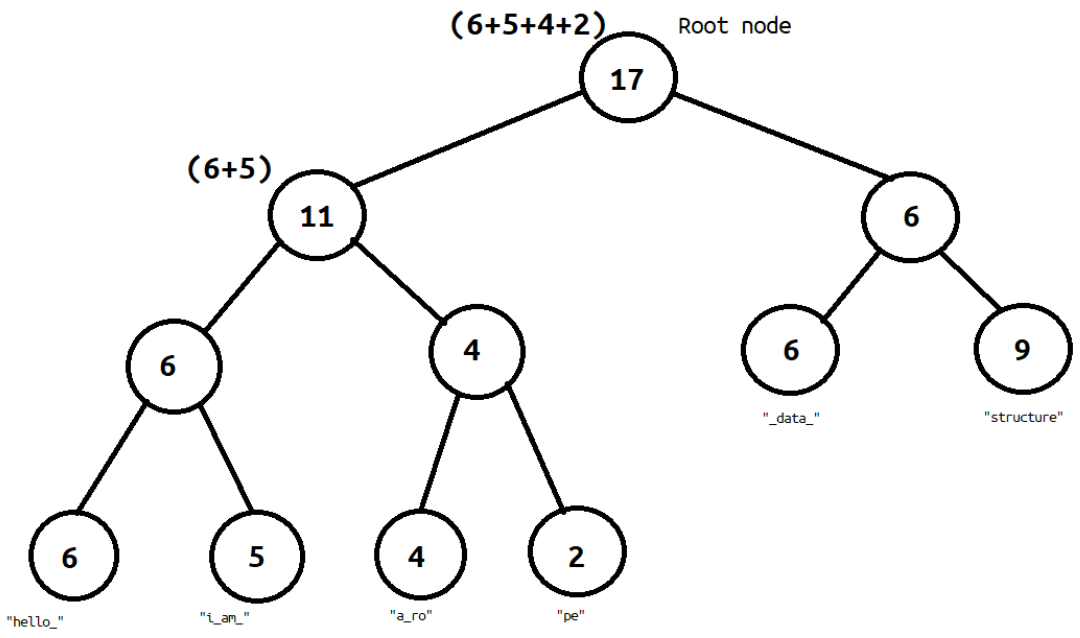


Fig 1 visualisation of rope data structure

The image shows how the string is stored in memory. Each leaf node contains substrings of the original string and all other nodes contain the number of characters present to the left of that node. The idea behind storing the number of characters to the left is to minimise the cost of finding the character present at it position.

Advantages of Rope data structure:

1. Ropes significantly reduce the cost of joining two strings.

2. Ropes do not require massive contiguous memory allocations, unlike arrays.

3. Ropes don't need O(n) extra memory for operations like insertion, deletion, and searching.

4. If a user wants to undo the previous concatenation, he can do so in O(1) time by simply removing the tree's root node.

THE BOYER-MOORE ALGORITHM

The B-M String search algorithm is a particularly efficient algorithm and has served as a standard benchmark for string search algorithm ever since.

The B-M algorithm takes a 'backward' approach: the pattern string (P) is aligned with the start of the text string (T), and then compares the characters of a pattern from right to left, beginning with rightmost character.

If a character is compared that is not within the pattern, no match can be found by analysing any further aspects at this position so the pattern can be changed entirely past the mismatching character.

3. METHODOLOGY

rope data structure is used in text editor by implementing the following things mentioned below:

I) Search

In order to find the character at i-th position, we search recursively beginning at the root node.

We follow the premise that if the weight of the current node is lower than the value of i, we subtract the weight from i & move right. If the weight is less than value of i we simply move left. We continue till the point we reach a leaf node.

Average case Time complexity: θ_n

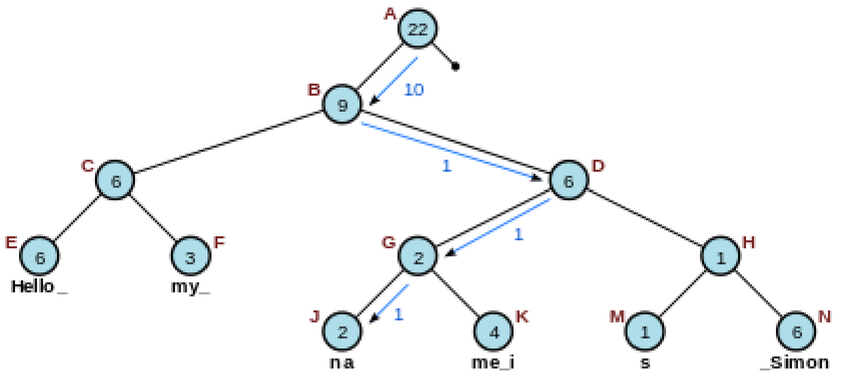


Fig 2 searching i-th position

For example, to find the character at i=10 in Figure 2 shown on the right, start at the root node (A), find that 22 is greater than 10 and there is a left child, so go to the left child (B). 9 is less than 10, so subtract 9 from 10 (leaving i=1) and go to the right child (D). Then because 6 is greater than 1 and there's a left child, go to the left child (G). 2 is greater than 1 and there's a left child, so go to the left child again (J). Finally, 2 is greater than 1 but there is no left child, so the character at index 1 of the short string "na" (i.e., "a") is the answer.

ii)Concatenation

A concatenation operation between 2 strings (S1 & S2) is performed by creation of a new root node which has a weight equal to the sum of weights of leaf nodes in S1. This takes time if the tree is already balanced. Since, most of the rope operations need a balanced tree, it might require re-balancing after the operation.

Time complexity: θ_n to concatenate strings and θlog_n to calculate weight of root.

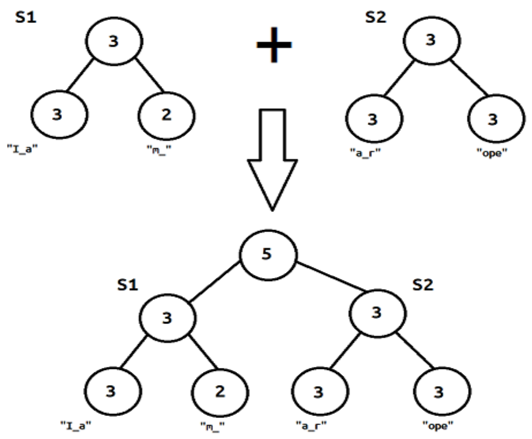


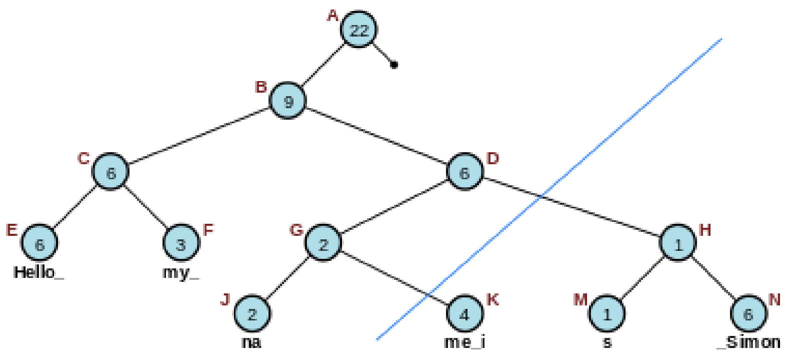
Fig 3 concatenation

iii)Split

In order to split a string at any given point i, there are 2 major cases we might encounter:

1. Split point being the last character of a leaf node.
2. Split point being a middle character of a leaf node.

With the second case, we can reduce it to the much simpler first one by splitting the string at given point into 2 leaf nodes & creating a new parent for these component strings. Follow this with subtracting the weights of the cut off parts from the parent nodes and re-balancing the tree.



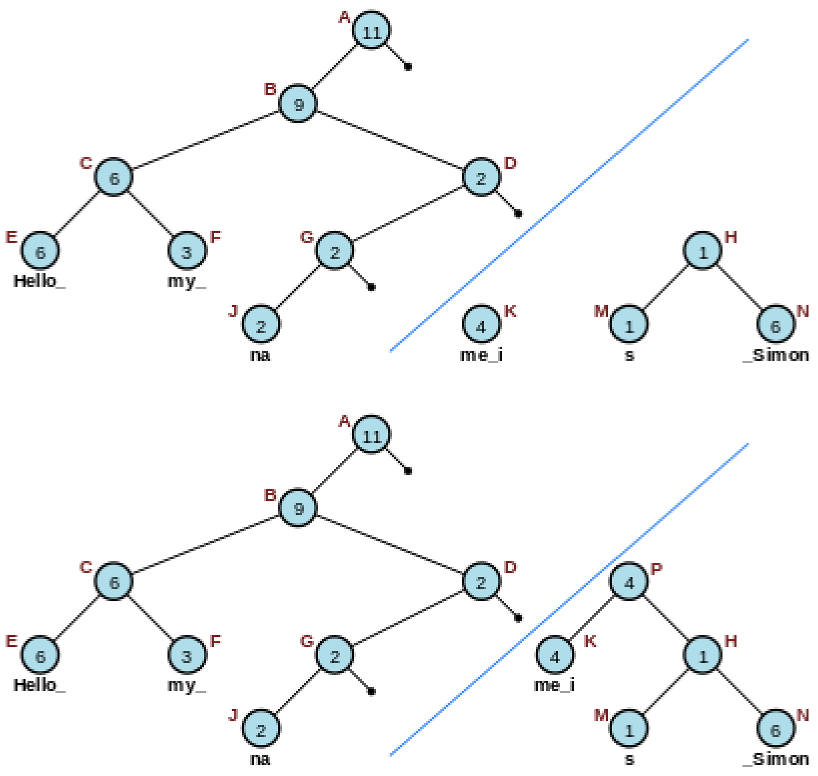


Fig 4 Splitting

For example, to split the 22-character rope pictured in Figure 4 into two equal component ropes of length 11, query the 12th character to locate the node K at the bottom level. Remove the link between K and G. Go to the parent of G and subtract the weight of K from the weight of D. Travel up the tree and remove any right links to subtrees covering characters past position 11, subtracting the weight of K from their parent nodes (only node D and A, in this case). Finally, build up the newly orphaned nodes K and H by concatenating them together and creating a new parent P with weight equal to the length of the left node K. As most rope operations require balanced trees, the tree may need to be re-balanced after splitting.

iv)Indexing

It means returning the character at position *I*

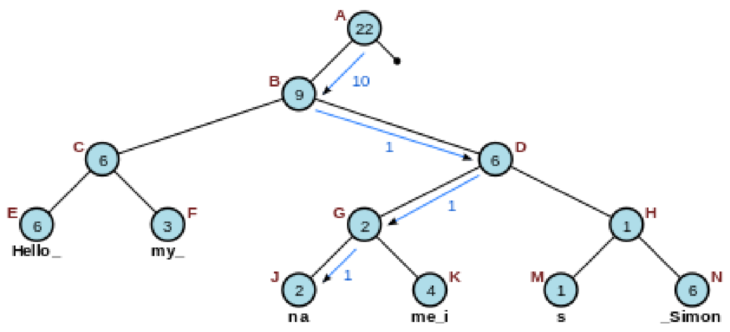


Fig 5 Indexing

For example, to find the character at i=10 in Figure 2 shown on the right, start at the root node (A), find that 22 is greater than 10 and there is a left child, so go to the left child (B). 9 is less than 10, so subtract 9 from 10 (leaving i=1) and go to the right child (D). Then because 6 is greater than 1 and there's a left child, go to the left child (G). 2 is greater than 1 and there's a left child, so go to the left child again (J). Finally, 2 is greater than 1 but there is no left child, so the character at index 1 of the short string "na" (i.e., "a") is the answer**.**

v)Insertion

In order to insert a string S' between our string, at position i, we simply need to split it at the index from which to insert, and the concatenate the new string followed by the split off part of the original string. The cost of this operation is the sum of the three operations performed.

vi)Deletion

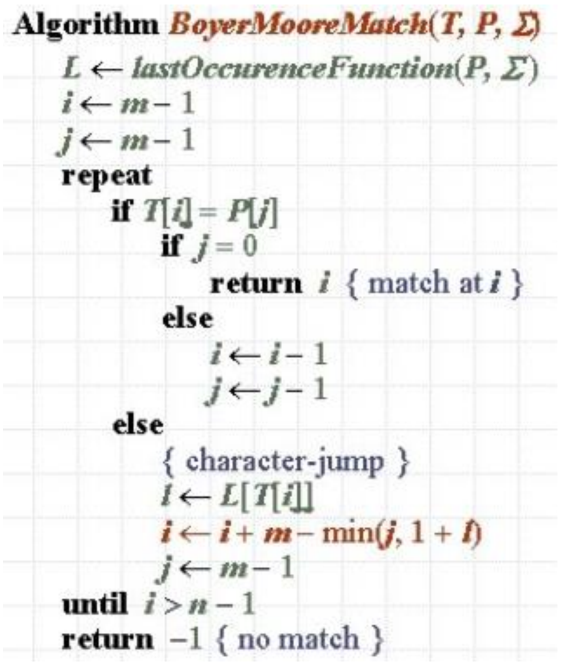
In order to delete a part of string from the middle, split the string at provided indices from ith to i+jth character and then concatenate the strings without the remaining part.

BM algorithm for find and search

The Boyer-Moore algorithm includes the most efficient string-matching algorithm compared to other string-matching algorithms due to an efficient nature of the algorithm, many string-matching algorithms developed based on the concept of Boyer-Moore algorithm, some of which are the Turbo BM algorithm and Quick Search algorithm, as for the string search steps on the Boyer-Moore algorithm as follows:

a) First, we need two tables with Match Heuristic (MH), and Occurrence Heuristic (OH) approaches to determine the number of shifts that will be performed on a pattern (P) if there are unsuitable characters in the matching process of characters in text (S).
b) If in the comparison process there is character mismatch between the characters on P and S, then the shift is done by looking at both tables with the largest shift value selected.
c) The possibility of completion in shifting to P is that if in previous matching there is no matching character then the shift is done by looking at the value of shift in occurrence heuristic table. If the character being compared does not exist in P, then the shift is done as much as the number of characters contained in P, but if the unsuitable character is contained in the P string, then the shift is done based on the table.
d) If the characters in the matching text match the characters on the P string, then the character checking position on P and S shifts each left position 1 from the previous position, then proceed with matching at that position and so on, then if there is a character mismatch In P and S, the shift is done by looking at the heuristic match table and the occurrence heuristic where the largest shift value to be selected is reduced by the number of matching characters.

e) If all the characters have a match, that means P has been found in S, then move the pattern by one character, continue until the end of the S pattern.



```
Algorithm BoyerMooreMatch($T$, $P$, $\Sigma$)
    $L \leftarrow$ lastOccurenceFunction($P$, $\Sigma$)
    $i \leftarrow m - 1$
    $j \leftarrow m - 1$
    repeat
        if $T[i] = P[j]$
            if $j = 0$
                return $i$ { match at $i$ }
            else
                $i \leftarrow i - 1$
                $j \leftarrow j - 1$
        else
            { character-jump }
            $l \leftarrow L[T[i]]$
            $i \leftarrow i + m - \min(j, 1 + l)$
            $j \leftarrow m - 1$
    until $i > n - 1$
    return $-1$ { no match }
```

Fig 6 Pseudo code of BM Algorithm

And we also used stack for implementing undo and redo operations in text editor.

4. DISCUSSION AND RESULT

We have created a text editor using skinter package in to GUI tool kit in python with the above-mentioned data structures and the pattern matching algorithm

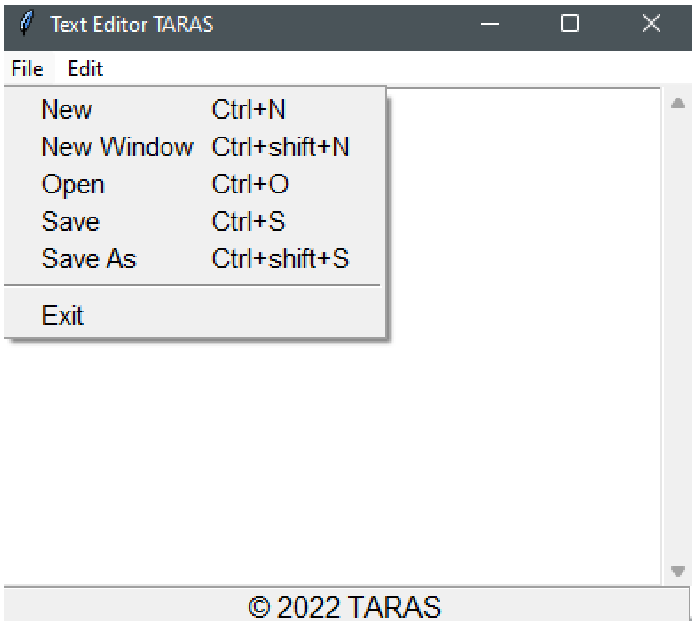


Fig7 File menu of the text editor

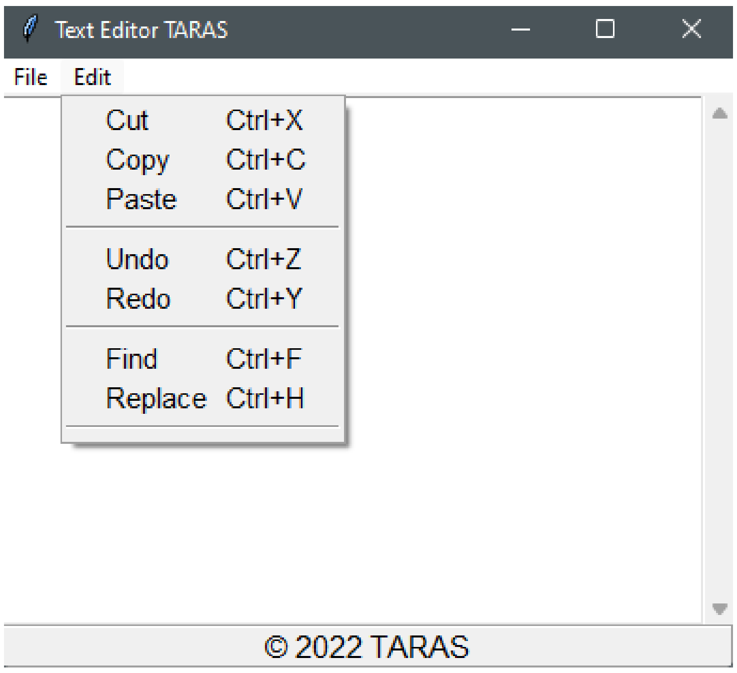
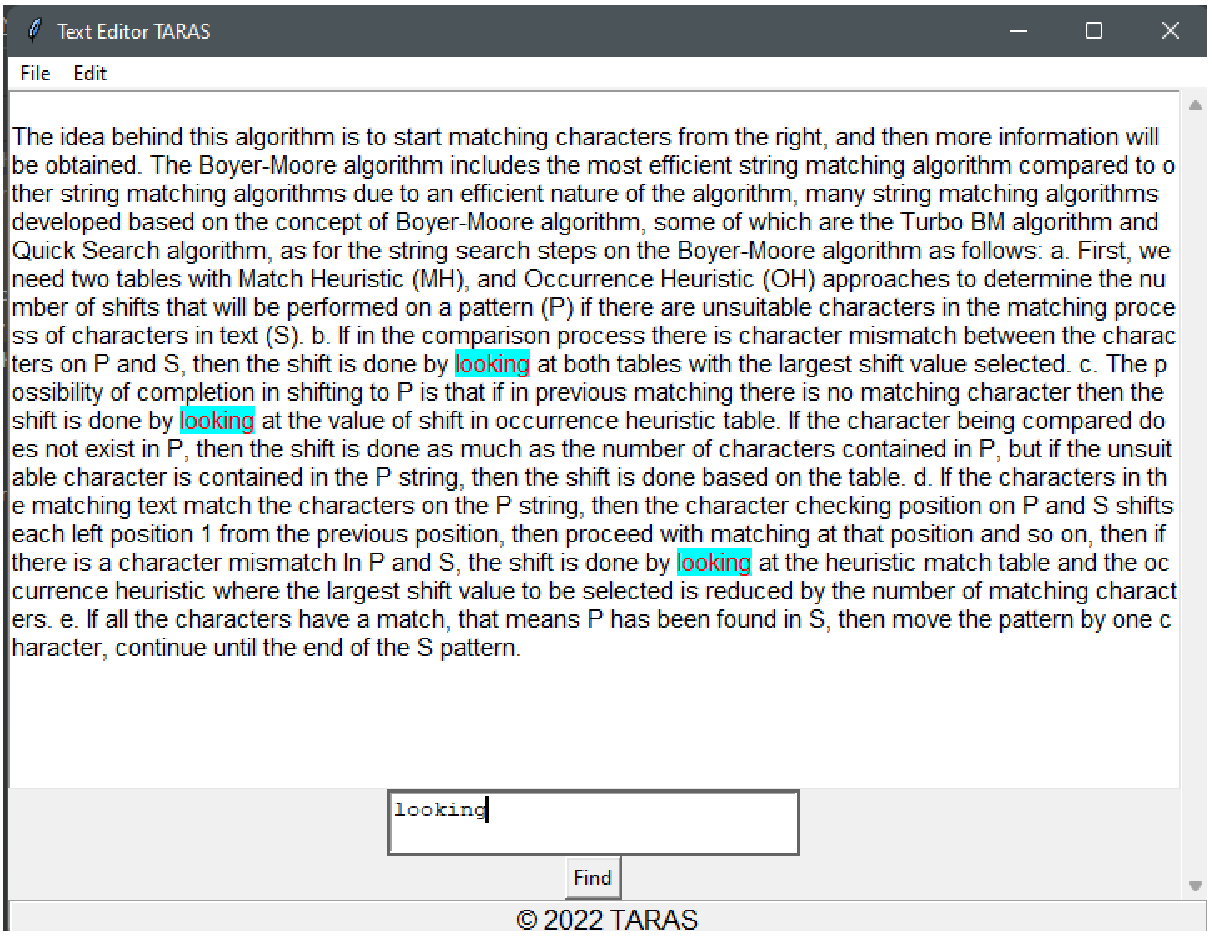
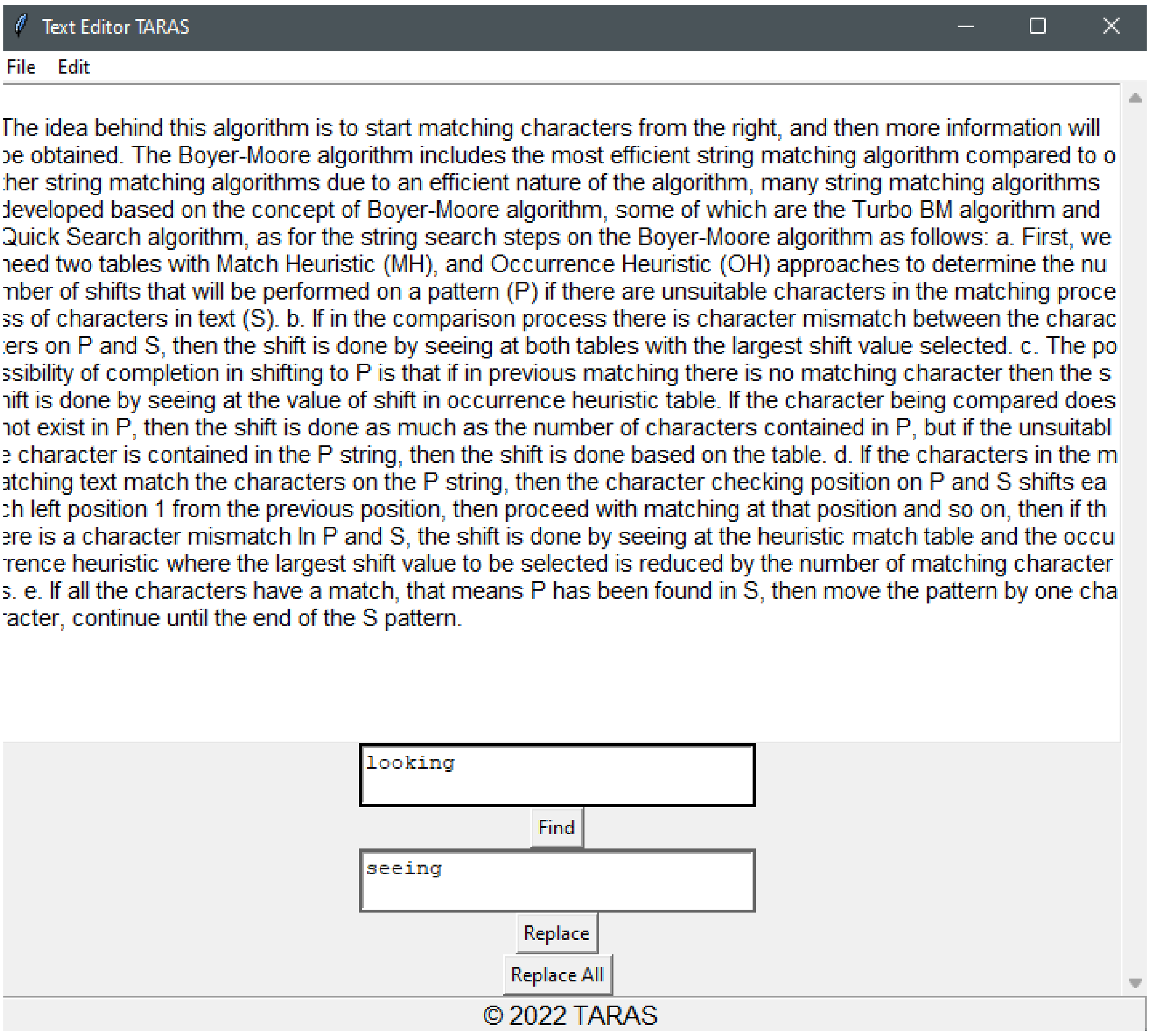


Fig 8 Edit menu of the text editor



The idea behind this algorithm is to start matching characters from the right, and then more information will be obtained. The Boyer-Moore algorithm includes the most efficient string matching algorithm compared to o ther string matching algorithms due to an efficient nature of the algorithm, many string matching algorithms developed based on the concept of Boyer-Moore algorithm, some of which are the Turbo BM algorithm and Quick Search algorithm, as for the string search steps on the Boyer-Moore algorithm as follows: a. First, we need two tables with Match Heuristic (MH), and Occurrence Heuristic (OH) approaches to determine the nu mber of shifts that will be performed on a pattern (P) if there are unsuitable characters in the matching proce ss of characters in text (S). b. If in the comparison process there is character mismatch between the charac ters on P and S, then the shift is done by looking at both tables with the largest shift value selected. c. The p ossibility of completion in shifting to P is that if in previous matching there is no matching character then the shift is done by looking at the value of shift in occurrence heuristic table. If the character being compared do es not exist in P, then the shift is done as much as the number of characters contained in P, but if the unsuit able character is contained in the P string, then the shift is done based on the table. d. If the characters in th e matching text match the characters on the P string, then the character checking position on P and S shifts each left position 1 from the previous position, then proceed with matching at that position and so on, then if there is a character mismatch In P and S, the shift is done by looking at the heuristic match table and the oc currence heuristic where the largest shift value to be selected is reduced by the number of matching charact ers. e. If all the characters have a match, that means P has been found in S, then move the pattern by one c haracter, continue until the end of the S pattern.

Fig 9 Find Edit Field of the text editor



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looking
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seeing
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Fig 10 Replace Edit Field of the text editor

5. CONCLUSION

In comparison to string arrays, where operations have a temporal complexity of O, ropes allow for substantially faster text insertion and deletion (n). When working with ropes, unlike arrays, which require O(n) extra memory for copying operations, there is no need for O(n) extra memory. It does not require vast contiguous memory spaces.

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