CSE5311 – 011 DESIGN AND ANALYSIS OF ALGORITHMS PROJECT 2 REPORT

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**HONOR CODE**

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## **Introduction:**

For this project, we have calculated the length of the Longest Common Subsequence of two strings by implementing Brute Force, Dynamic Programming and Dynamic programming with two arrays methods. As the result, we have displayed the length of LCS and the time taken for the algorithm to calculate it but, for Dynamic programming with two arrays method we have displayed the two arrays side by side as per the requirements.

## **1.1 Individual Contribution:**

Vignesh Manikandan: Worked on LCS\_DP\_CB, LCS\_DP and project report.

Ruban Eswaravelu: Worked on LCS\_BF, LCS\_DP and project report.

Both members of the group gave equal contributions on LCS\_DP and report and individually worked on LCS\_DP\_CB and LCS\_BF.

# **2. Time complexities of the algorithms:**

* Time Complexity of the LCS algorithm using the Brute force approach is O(n \* 2n).
* Time Complexity of the LCS algorithm using the Dynamic programming approach is O(m\*n).
* Time Complexity of the LCS algorithm using the Dynamic programming with two arrays approach is O(m\*n).

# **3. Output**

## **3.1 LCS\_BF.java**

String 1="BillBoard" String 2="BoardBill"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 575900ns

String 1="BillBoard" String 2="BoardBill1"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 143900ns

String 1="BillBoard" String 2="BoardBill12"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 201400ns

String 1="BillBoard" String 2="BoardBill123"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 307200ns

String 1="BillBoard" String 2="BoardBill1234"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 513600ns

String 1="BillBoard" String 2="BoardBill12345"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 707500ns

String 1="BillBoard" String 2="BoardBill123456"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 1027100ns

String 1="BillBoard" String 2="BoardBill1234567"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 1970900ns

String 1="BillBoard" String 2="BoardBill1234567B"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 1990100ns

String 1="BillBoard" String 2="BoardBill1234567Bo"

Length of the Longest Common Subsequence of the two strings is 6

Time taken to find the length is 2868200ns

String 1="BillBoard" String 2="BoardBill1234567Boa"

Length of the Longest Common Subsequence of the two strings is 7

Time taken to find the length is 3389600ns

String 1="BillBoard" String 2="BoardBill1234567Boar"

Length of the Longest Common Subsequence of the two strings is 8

Time taken to find the length is 3478700ns

String 1="BillBoard" String 2="BoardBill1234567Board"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 4000ns

String 1="BillBoard" String 2="BoardBill1234567Board1"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 312100ns

String 1="BillBoard" String 2="BoardBill1234567Board12"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 1635100ns

String 1="BillBoard" String 2="BoardBill1234567Board123"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 3108600ns

String 1="BillBoard" String 2="BoardBill1234567Board1234"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 4445300ns

String 1="BillBoard" String 2="BoardBill1234567Board12345"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 8321200ns

String 1="BillBoard" String 2="BoardBill1234567Board123456"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 14995000ns

String 1="BillBoard" String 2="BoardBill1234567Board1234567"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 21739000ns

Text

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## **3.2 LCS\_DP.java**

String 1="BillBoard" String 2="BoardBill"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 29000ns

String 1="BillBoard" String 2="BoardBill1"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 13100ns

String 1="BillBoard" String 2="BoardBill12"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 11800ns

String 1="BillBoard" String 2="BoardBill123"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 15500ns

String 1="BillBoard" String 2="BoardBill1234"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 17900ns

String 1="BillBoard" String 2="BoardBill12345"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 12600ns

String 1="BillBoard" String 2="BoardBill123456"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 18200ns

String 1="BillBoard" String 2="BoardBill1234567"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 13100ns

String 1="BillBoard" String 2="BoardBill1234567B"

Length of the Longest Common Subsequence of the two strings is 5

Time taken to find the length is 15300ns

String 1="BillBoard" String 2="BoardBill1234567Bo"

Length of the Longest Common Subsequence of the two strings is 6

Time taken to find the length is 14100ns

String 1="BillBoard" String 2="BoardBill1234567Boa"

Length of the Longest Common Subsequence of the two strings is 7

Time taken to find the length is 18200ns

String 1="BillBoard" String 2="BoardBill1234567Boar"

Length of the Longest Common Subsequence of the two strings is 8

Time taken to find the length is 14200ns

String 1="BillBoard" String 2="BoardBill1234567Board"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 19000ns

String 1="BillBoard" String 2="BoardBill1234567Board1"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 46900ns

String 1="BillBoard" String 2="BoardBill1234567Board12"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 27500ns

String 1="BillBoard" String 2="BoardBill1234567Board123"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 27200ns

String 1="BillBoard" String 2="BoardBill1234567Board1234"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 24700ns

String 1="BillBoard" String 2="BoardBill1234567Board12345"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 27600ns

String 1="BillBoard" String 2="BoardBill1234567Board123456"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 24800ns

String 1="BillBoard" String 2="BoardBill1234567Board1234567"

Length of the Longest Common Subsequence of the two strings is 9

Time taken to find the length is 26300ns

Text

Description automatically generated

Text

Description automatically generated

## **3.3 LCS\_DP\_CB.java**

X="Bat" Y="Boa"

++++++++++++++++++++++++++++++++++++

Y B o a

X 0 0 0 0

B 0 \ 1 < 1 < 1

a 0 ^ 1 ^ 1 \ 2

t 0 ^ 1 ^ 1 ^ 2

++++++++++++++++++++++++++++++++++++

Length of the Longest Common Subsequence is: 2

The Longest Common Subsequence of "Bat" and "Boa" is "Ba"

Time taken to find the length is 21700ns

X="Bogart" Y="Bart"

++++++++++++++++++++++++++++++++++++

Y B a r t

X 0 0 0 0 0

B 0 \ 1 < 1 < 1 < 1

o 0 ^ 1 ^ 1 ^ 1 ^ 1

g 0 ^ 1 ^ 1 ^ 1 ^ 1

a 0 ^ 1 \ 2 < 2 < 2

r 0 ^ 1 ^ 2 \ 3 < 3

t 0 ^ 1 ^ 2 ^ 3 \ 4

++++++++++++++++++++++++++++++++++++

Length of the Longest Common Subsequence is: 4

The Longest Common Subsequence of "Bogart" and "Bart" is "Bart"

Time taken to find the length is 8400ns

X="Popper" Y="Paper"

++++++++++++++++++++++++++++++++++++

Y P a p e r

X 0 0 0 0 0 0

P 0 \ 1 < 1 < 1 < 1 < 1

o 0 ^ 1 ^ 1 ^ 1 ^ 1 ^ 1

p 0 ^ 1 ^ 1 \ 2 < 2 < 2

p 0 ^ 1 ^ 1 \ 2 ^ 2 ^ 2

e 0 ^ 1 ^ 1 ^ 2 \ 3 < 3

r 0 ^ 1 ^ 1 ^ 2 ^ 3 \ 4

++++++++++++++++++++++++++++++++++++

Length of the Longest Common Subsequence is: 4

The Longest Common Subsequence of "Popper" and "Paper" is "Pper"

Time taken to find the length is 7200ns

X="Panther" Y="Partner"

++++++++++++++++++++++++++++++++++++

Y P a r t n e r

X 0 0 0 0 0 0 0 0

P 0 \ 1 < 1 < 1 < 1 < 1 < 1 < 1

a 0 ^ 1 \ 2 < 2 < 2 < 2 < 2 < 2

n 0 ^ 1 ^ 2 ^ 2 ^ 2 \ 3 < 3 < 3

t 0 ^ 1 ^ 2 ^ 2 \ 3 ^ 3 ^ 3 ^ 3

h 0 ^ 1 ^ 2 ^ 2 ^ 3 ^ 3 ^ 3 ^ 3

e 0 ^ 1 ^ 2 ^ 2 ^ 3 ^ 3 \ 4 < 4

r 0 ^ 1 ^ 2 \ 3 ^ 3 ^ 3 ^ 4 \ 5

++++++++++++++++++++++++++++++++++++

Length of the Longest Common Subsequence is: 5

The Longest Common Subsequence of "Panther" and "Partner" is "Paner"

Time taken to find the length is 10200ns

Text

Description automatically generated

Text

Description automatically generated

# **4. Results:**

We are measuring the time taken by the algorithm for calculating the length of the LCS by nanoseconds. The time taken by each of the algorithms to calculate the length of the LCS are in the below table:

|  |  |  |  |
| --- | --- | --- | --- |
| **String 1** | **String 2** | **LCS\_BF** | **LCS\_DP** |
| BillBoard | BillBoard | 575900ns | 29000ns |
| BillBoard | BoardBill1 | 143900ns | 13100ns |
| BillBoard | BoardBill12 | 201400ns | 11800ns |
| BillBoard | BoardBill123 | 307200ns | 15500ns |
| BillBoard | BoardBill1234 | 513600ns | 17900ns |
| BillBoard | BoardBill12345 | 707500ns | 12600ns |
| BillBoard | BoardBill123456 | 1027100ns | 18200ns |
| BillBoard | BoardBill1234567 | 1970900ns | 13100ns |
| BillBoard | BoardBill1234567B | 1990100ns | 15300ns |
| BillBoard | BoardBill1234567Bo | 2868200ns | 14100ns |
| BillBoard | BoardBill1234567Boa | 3389600ns | 18200ns |
| BillBoard | BoardBill1234567Boar | 3478700ns | 14200ns |
| BillBoard | BoardBill1234567Board | 4000ns | 19000ns |
| BillBoard | BoardBill1234567Board1 | 312100ns | 46900ns |
| BillBoard | BoardBill1234567Board12 | 1635100ns | 27500ns |
| BillBoard | BoardBill1234567Board123 | 3108600ns | 27200ns |
| BillBoard | BoardBill1234567Board1234 | 4445300ns | 24700ns |
| BillBoard | BoardBill1234567Board12345 | 8321200ns | 27600ns |
| BillBoard | BoardBill1234567Board123456 | 14995000ns | 24800ns |
| BillBoard | BoardBill1234567Board1234567 | 21739000ns | 26300ns |

From the table we can see that the dynamic programming approach takes less time to calculate the length LCS of two strings than the brute force approach.

Below table shows the time taken by the algorithm to calculate the length of the LCS of the two strings X and Y. From the table we can see that the algorithm takes less time for strings which are small.

|  |  |  |
| --- | --- | --- |
| **String ‘X’** | **String ‘Y’** | **Time taken** |
| Bat | Boa | 21700ns |
| Bogart | Bart | 8400ns |
| Popper | Paper | 7200ns |
| Panther | Partner | 10200ns |

# **5. Text files:**

## **5.1 LCS1.txt:**

BillBoard,BoardBill

BillBoard,BoardBill1

BillBoard,BoardBill12

BillBoard,BoardBill123

BillBoard,BoardBill1234

BillBoard,BoardBill12345

BillBoard,BoardBill123456

BillBoard,BoardBill1234567

BillBoard,BoardBill1234567B

BillBoard,BoardBill1234567Bo

BillBoard,BoardBill1234567Boa

BillBoard,BoardBill1234567Boar

BillBoard,BoardBill1234567Board

BillBoard,BoardBill1234567Board1

BillBoard,BoardBill1234567Board12

BillBoard,BoardBill1234567Board123

BillBoard,BoardBill1234567Board1234

BillBoard,BoardBill1234567Board12345

BillBoard,BoardBill1234567Board123456

BillBoard,BoardBill1234567Board1234567

## **5.2 LCS2.txt**

Bat,Boa

Bogart,Bart

Popper,Paper

Panther,Partner

# **6.References:**

* Introduction to Algorithms, third edition, Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein.
* [GeeksforGeeks | A computer science portal for geeks](https://www.geeksforgeeks.org/)