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CS 325 – Analysis of Algorithms
Implementation 2 – Report
2/23/2017

Pseudo-Code:

```
minDistance( str1, str2 ):

    # Check base cases
    if length( str1 ) == 0:
        return length( str2 )*2
    if length( str2 ) == 0:
        return length( str1 )*2

    len1 = length( str1 ) + 1
    len2 = length( str2 ) + 1

    # Create distanceMatrix[ len1 ][ len2 ]
    for i = 0 … len1:
        for j = 0 … len2:
            delete = distanceMatrix[ i-1 ][ j ] + 1
            insert = distanceMatrix[ i ][ j-1 ] + 1
            substitute = distanceMatrix[ i-1 ][ j-1 ]

            if str1[ i-1 ] != str2[ j-1 ]:
                substitute += 2

            distanceMatrix[ i ][ j ] = min { delete, insert, substitute }

call traceback
return distanceMatrix[ len1 ][ len2 ]
```

```
traceback ( first, second, distanceMatrix ):

    i = length( first );   j = length( second )
    while ( i = length( first ) > 0 ):
        # Check if we are traversing left, down, or diagonal
        if (DIAGONAL) <= (LEFT) & (DOWN):
            i -= 1;  j -= 1
            str1 = first[i] + str1
            str2 = second[j] + str2
```

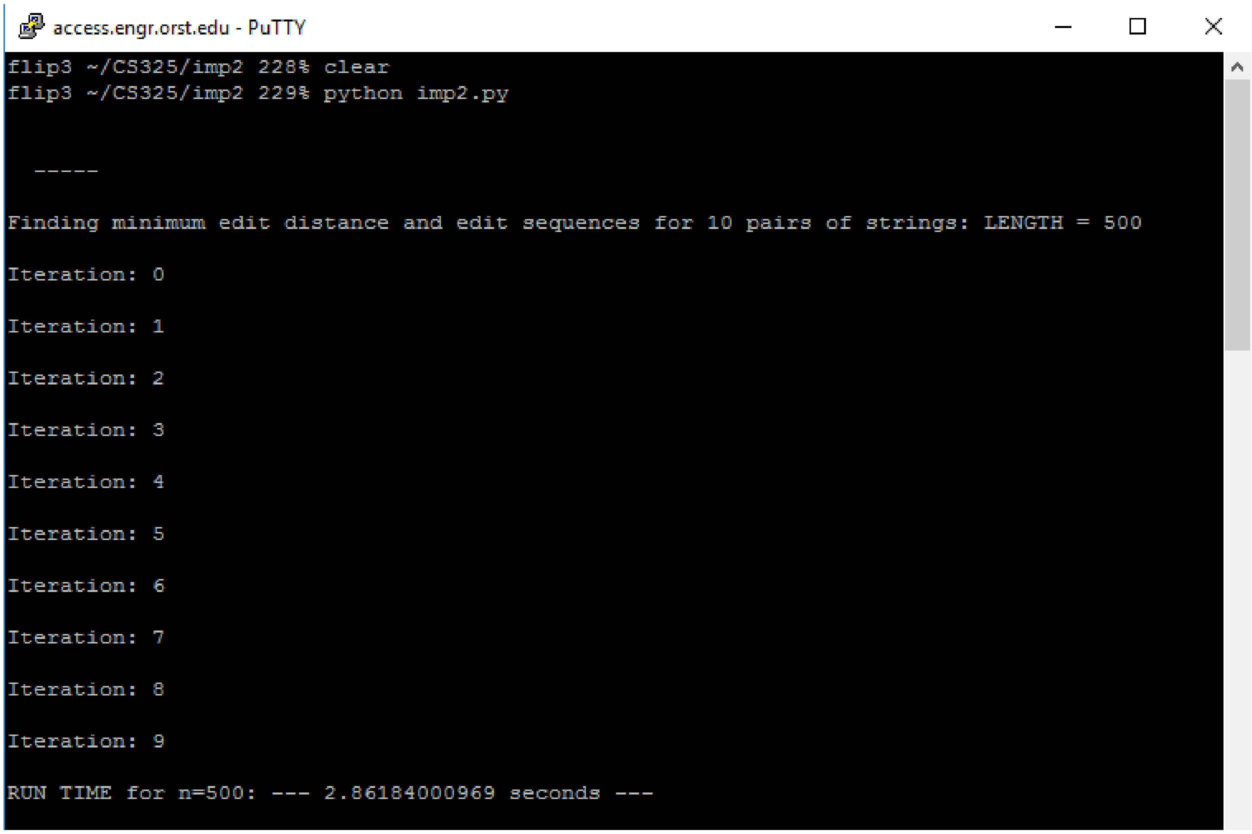
```
# Traceback continued…
    elif (DOWN) <= (LEFT) & (DIAGONAL):
        i -= 1

        str1 = first[i] + str1
        str2 = "-" +  str2
    else:
        j -= 1
        str1 = "-" + str1
        str2 = second[j]+ str2

# If we reach end of a string, add “-“ to front of completed string and
#                                 add the remaining characters to other string
    if (j <= 0):
        while (i != 0):
            i -= 1
            str1 = first[i] + str1
            str2 = "-" +  str2
        break
    elif (i <= 0):
        while (j != 0):
            j -= 1
            str1 = "-" + str1
            str2 = second[j] + str2
        break

return str1 + “,” + str2
```

Asymptotic Analysis of Run Time:

If N is the length of the longer of the two strings, and D is the minimum edit distance between the two strings, the most optimized runtime for finding the minimum distance and reconstructing the edit sequences of the two strings would be O(n + d^2). Worst case, we must traverse through the entire length of the longest string to compare against the other string and to find the minimum distance between the two; this gives us the “n”. We then must add “d^2,” which represents the worst-case runtime for reconstructing the edit sequences. At its worst, string1 and string2 are nothing alike and we must traverse the entire minimum edit distance (d) for each value in the minimum edit distance path.

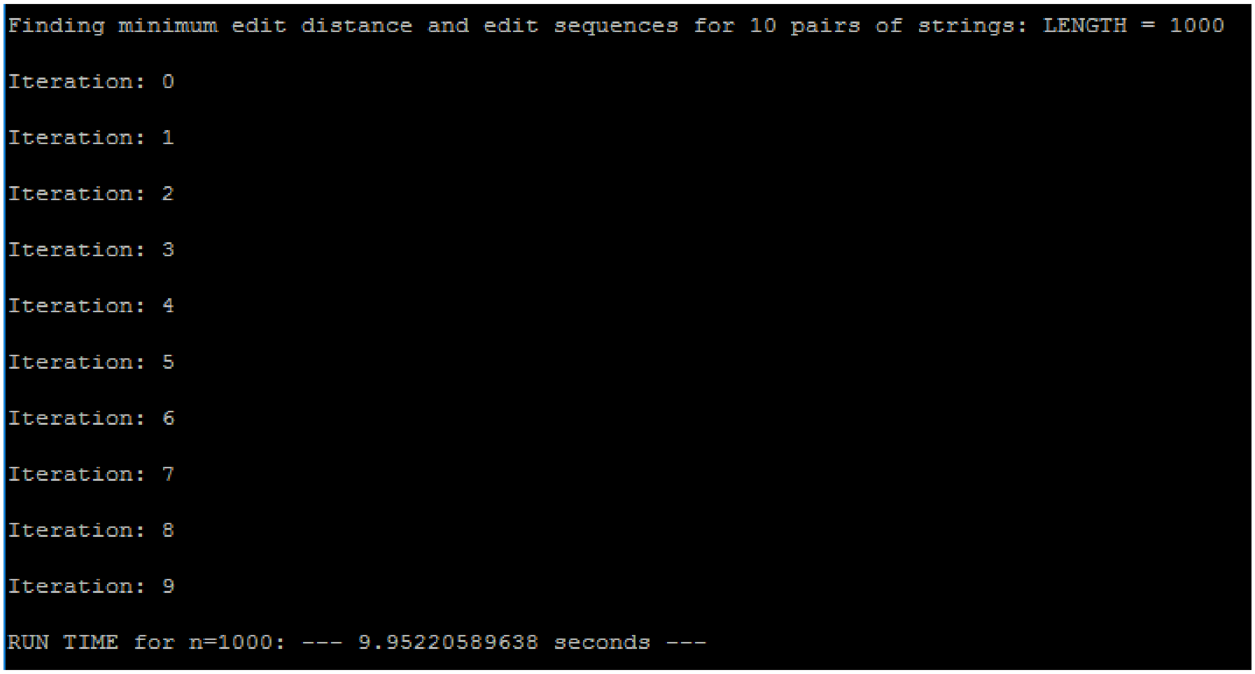
Recording and Plotting of Run Time:

N = 500



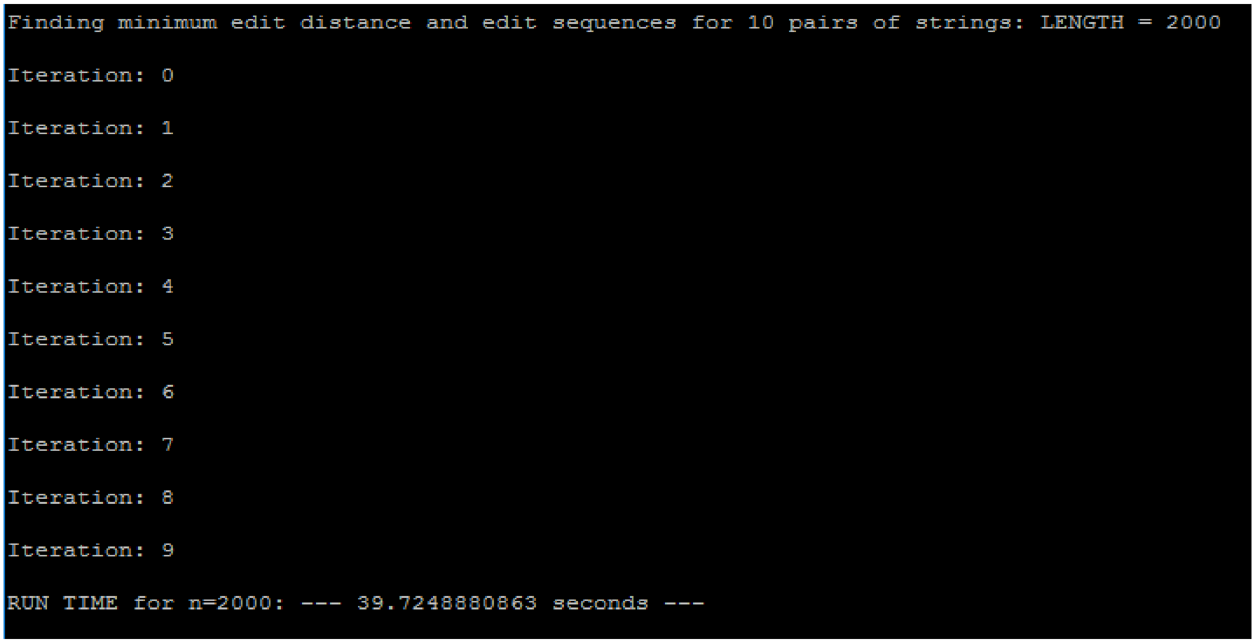
```
flip3 ~/CS325/imp2 228% clear
flip3 ~/CS325/imp2 229% python imp2.py


  -----

Finding minimum edit distance and edit sequences for 10 pairs of strings: LENGTH = 500

Iteration: 0

Iteration: 1

Iteration: 2

Iteration: 3

Iteration: 4

Iteration: 5

Iteration: 6

Iteration: 7

Iteration: 8

Iteration: 9

RUN TIME for n=500: --- 2.86184000969 seconds ---
```

N = 1000



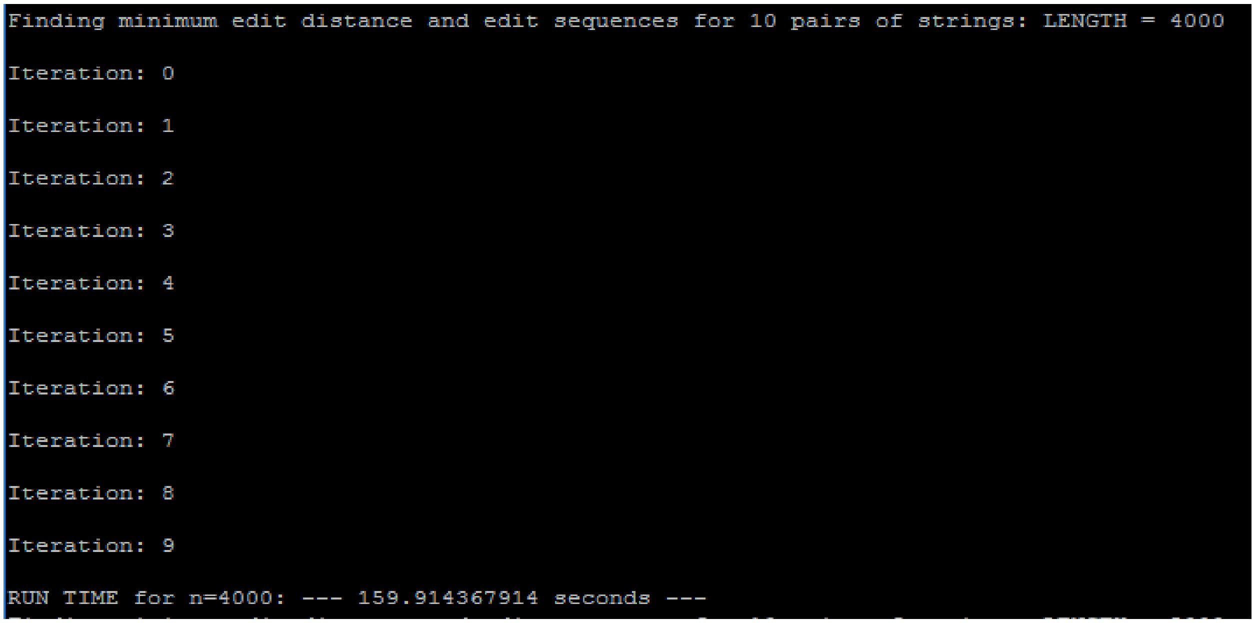
```
Finding minimum edit distance and edit sequences for 10 pairs of strings: LENGTH = 1000

Iteration: 0

Iteration: 1

Iteration: 2

Iteration: 3

Iteration: 4

Iteration: 5

Iteration: 6

Iteration: 7

Iteration: 8

Iteration: 9

RUN TIME for n=1000: --- 9.95220589638 seconds ---
```

N = 2000



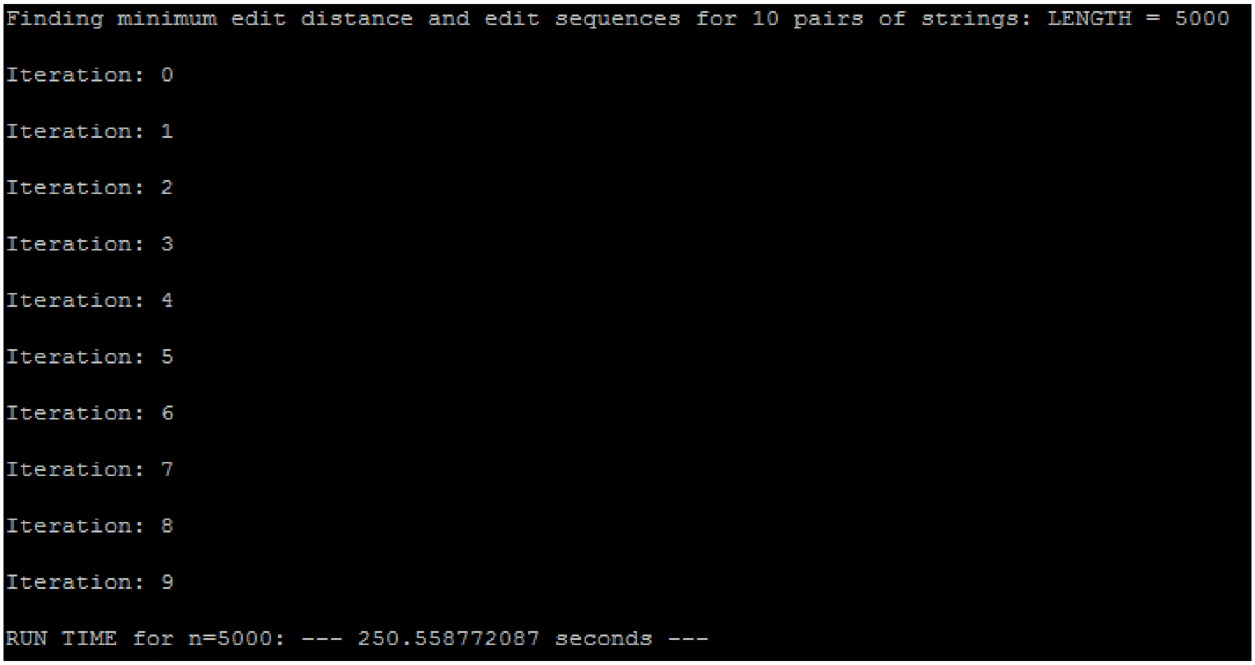
```
Finding minimum edit distance and edit sequences for 10 pairs of strings: LENGTH = 2000

Iteration: 0

Iteration: 1

Iteration: 2

Iteration: 3

Iteration: 4

Iteration: 5

Iteration: 6

Iteration: 7

Iteration: 8

Iteration: 9

RUN TIME for n=2000: --- 39.7248880863 seconds ---
```

N = 4000



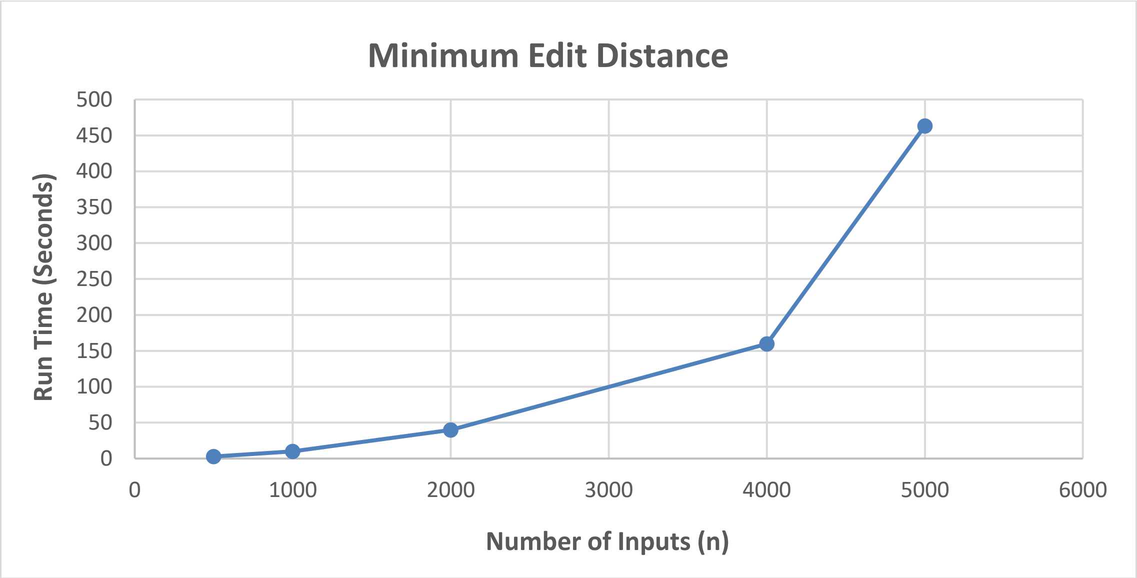
```
Finding minimum edit distance and edit sequences for 10 pairs of strings: LENGTH = 4000

Iteration: 0

Iteration: 1

Iteration: 2

Iteration: 3

Iteration: 4

Iteration: 5

Iteration: 6

Iteration: 7

Iteration: 8

Iteration: 9

RUN TIME for n=4000: --- 159.914367914 seconds ---
```

N = 5000



```
Finding minimum edit distance and edit sequences for 10 pairs of strings: LENGTH = 5000

Iteration: 0

Iteration: 1

Iteration: 2

Iteration: 3

Iteration: 4

Iteration: 5

Iteration: 6

Iteration: 7

Iteration: 8

Iteration: 9

RUN TIME for n=5000: --- 250.558772087 seconds ---
```

Plotting Run Time vs. Number of Inputs:



Interpretation and Discussion:

I initially programmed “imp2.py” using the naïve approach to test the differences between it and the more optimized approach. When I did this, I found (as expected) that the more I increased M and N (lengths of string1 and string2), the runtime increased exponentially. Then I began to program the more optimized approach, which I found to be significantly faster.

Using the run time data above, I found that run time would still increase dramatically the greater the length of the strings. Below is a table demonstrating the supposed runtime using the optimized runtime formula, **O(n + d^2)**:

N	D (on average)	Calculated Run Time	Actual Run Time
500	360	1.30100	2.86184
1000	702	4.93804	9.952205
2000	1388	19.28544	39.72488
4000	2794	78.10436	159.91436
5000	3464	120.04296	250.55877

As you can see, I didn't quite hit the most optimized runtime. In fact, for all values of n (n = 500, 1000, 2000, 4000, and 5000), it seems that my run times were just over double the calculated runtime. This is most likely because I would open and close the "imp2input.txt" and "imp2output.txt" files on every iteration to ensure the files would not become corrupted during processing. Though there were some additional seconds added to the each of the runtimes, all my actual runtimes still follow a consistent growth ratio to that of the optimized runtime, just as a multiple of 2.