CPSC 335 - Algorithm Engineering
Project 1: Implementing Algorithms

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Names, CSUF Email, and Intent

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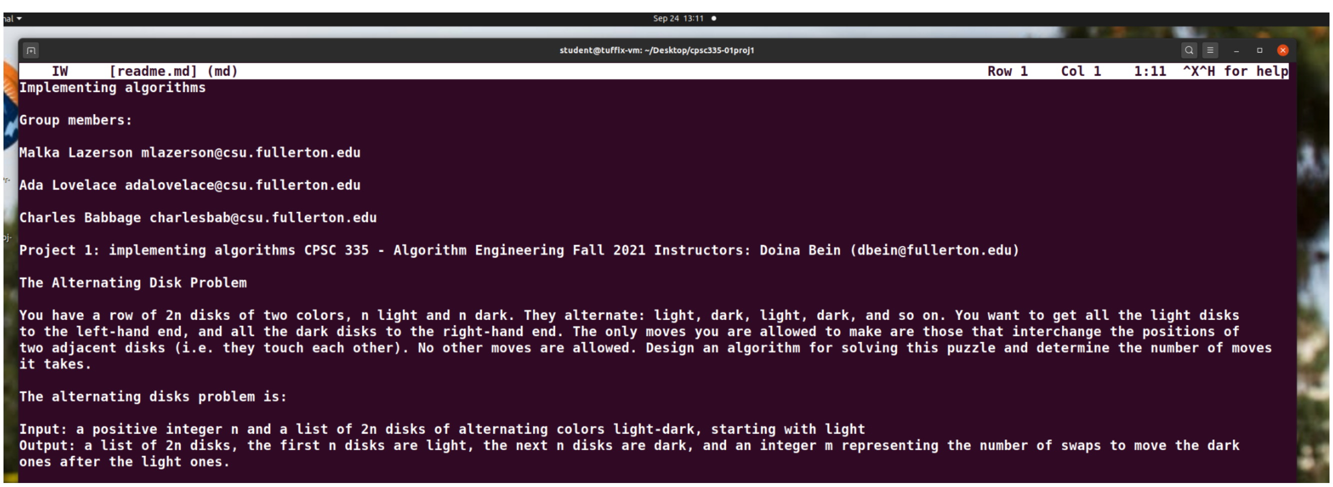
Intent: This document is intended to be one part of a submission for Project 1: Implementing Algorithms. This document contains….

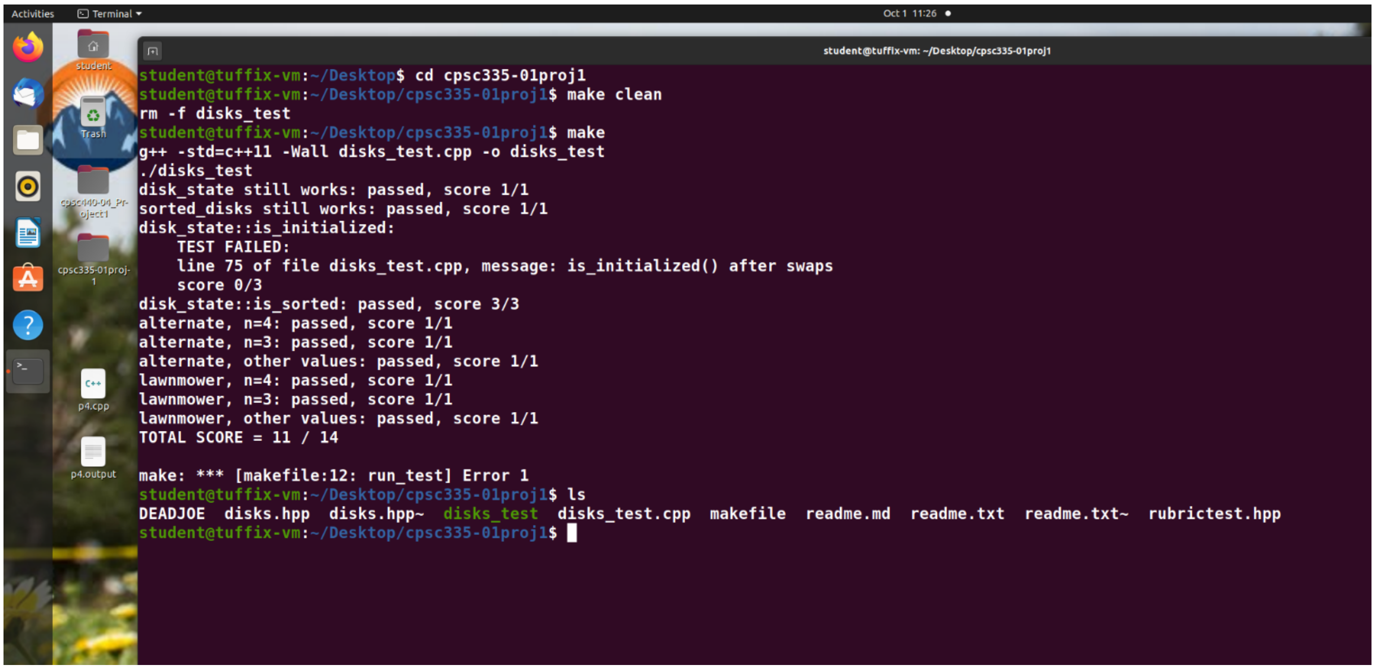
1. The name of the student working on this project, the CSUF-supplied email address of said student, and an indication that the submission is for project 1.
2. A full-screen screenshot, inside Tuffix, of the readme.txt document opened by the jmacs editor containing the students name.
3. A full-screen screenshot showing your code compiling and executing.
4. Two pseudocode listings, for the two algorithms, and their step count.
5. A brief proof argument for the time complexity of your two algorithms.

Code will be placed in the github files for the instructor to review

ReadMe.md Screenshot



Code Compilation and Execution



Pseudocode and Step Count

Lawn Mower Algorithm Pseudocode

..................Details..

- Check indices to sort the disks
- Runs 2n times
- Compare d[0] and d[1], then d[1] and d[2], etc.
- Because we got left, right left, right, we compare d[0] and d[1], then d[1] and d[2], d[2] and d[3]...and then d[3] and d[2], then d[2] and d[1], and lastly d[1] and d[0]
- D = dark, L = light

```
//....................Pseudocode: Lawn Mower Algorithm.......................................................................
//record number of swap for return
NumSwaps = 0

//main for loop
for i=0 to (n+1)/2 do:

   //if starting on left side
          for j=i+1 to 2n-2 do:

                    //if and only if left = D and right= L
                    if disk[j] is D and disk[j+1] is L

                              swap disk[j] and disk[j+1]
                              NumSwaps++;

   //if starting on right side
   for j=2n-1 down to 1 do:

              //if and only if left = D and right= L
              if disk[j-1] is D and disk[j] is L

                       swap disk[j-1] and disk[j]
                       NumSwaps++;

return NumSwaps;
```

....................................STEP COUNT..

```
//record number of swap for return
NumSwaps = 0 // 1  time

//main for loop
for i=0 to (n+1)/2 do: // (n+1)/2 times

  //if starting on left side
        for j=i+1 to 2n-2 do: // n/2 times

                //if and only if left = D and right= L
                if disk[j]== D and disk[j+1]== L // 3 times

                        swap disk[j] and disk[j+1] // 1 time
                        NumSwaps++;// 1 time

  //if starting on right side
  for j=2n-1 down to 1 do: // n/2 times

          //if and only if left = D and right= L
          if disk[j-1]== D and disk[j]== L // 3 times

                  swap disk[j-1] and disk[j] // 1 time
                  NumSwaps++;// 1 time

return NumSwaps;//1 time
```

.....................................STEP COUNT CALCULATIONS...

1 + ((n+1)/2) * (((n/2) * 3 + 1 + 1) + ((n/2) * 3 + 1 + 1)) + 1 =
1 + ()(n+1)/2) * (((n/2) * 5) + ((n/2) * 5)) + 1 =
((n+1)/2) * (((n/2) * 5) + ((n/2) * 5)) + 2 =
((n+1)/2) * ((5n/2) + (5n/2)) + 2 =
((n+1)/2) * (10n/2) + 2 =

Simplify

(10n^2 + 10n) / (2) + 2 =
5n^2 + 5n + 2

ANSWER: 5n^2 + 5n + 2

Alternate Algorithm Pseudocode

..................Details..

- check PAIRS, not indices, to sort the disks
- algorithm has n+1 runs
- compare d[0] and d[1], then d[2] and d[3], etc.
- D = dark, L = light

...................Pseudocode: Alternate Algorithm..

```
//record number of swap for return
NumSwaps = 0

//To move by 2 spaces/1 pair each time....
// i=i+2 leads to outer for loop having i = 0,2,4,8...
//alternating algorithm has n+1 runs
for i=0 to n do:

   //to get 1 space for right most of the pair...
   //j=i/2 = 1,2,3,4...
   for j=i%2 to 2n-2 step 2 do:

            if disks[j] is D and disks[j+1] is L

                    swap disks[j] and disks[j+1]
                    NumSwaps++;

return NumSwaps;
```

...................................STEP COUNT..

```
//record number of swap for return
NumSwaps = 0 //1 time

//To move by 2 spaces/1 pair each time....
// i=i+2 leads to outer for loop having i = 0,2,4,8...even half of n
for i=0 to n do: //outer loop runs n+1 times
```

```
  //to get 1 space for right most of the pair...
  //j= i mod 2 = 1,3,5,7...odd half of n
  for j=i%2 to 2n-2 step 2 do: //inner loop runs n/2 times


        if disks[j] is D and disks[j+1] is L // 3 times

              swap disks[j] and disks[j+1] //1 time
              NumSwaps++;// 1 time

return NumSwaps; // 1 time
```

....................................STEP COUNT CALCULATIONS...

1 + ((n+1) * ((n/2) * (3 + 1 +1)) + 1 =
(n+1) * ((n/2) * 5) + 2 =
(n+1) * (5n/2) + 2 =
5n^2+5n/2 + 2

(5n^2 + 5n) / (2) + 2

Clean up by clearing denominator

(2) * (5n^2 + 5n) /(2) + 2 =

10n^2 + 10n + 2

ANSWER: 10n^2 + 10n + 2

Time Complexity

Lawn Mower Algorithm Time Complexity

5n^2 + 5n + 2 looks to be 0(n^2), but proof is needed.

"O(f(n)) = {g(n)| there exists some constants c > 0 and t ≥ 0 such that g(n) ≤ c·f(n) whenever n ≥ t}."

BASE CASE: “n” is defined when $n = 0$, as proven below…..

$5n^2 + 5n + 2 <= c * f(n)$

$c > 5n + 5 + 2/n$
So we will use $t = 1$

$t(n) = 5(1)^2 + 5(1) + 2 =$
$5 + 5 + 2 = 12$

$c*f(n) = 12n = 12(1) = 12$

So $12 <= 12$, proving there exists a constant $c > 0$ and $t >= 0$ such that $g(n) <= c * f(n)$ if $n >= t$

INDUCTIVE STEP: If $n > t$ and $T(n) \leq c \cdot f(n)$, then $T(n + 1) \leq c \cdot f(n + 1)$.....

Let $T(n) \leq c * f(n)$....

$5n^2 + 5n + 2 <= 12n$

$$\begin{array}{l} \qquad\qquad\quad +2 \qquad\qquad + 12 \\ 5n^2 + 5n + 4 <= 12n + 12 \end{array}$$

$5 (n^2 + n) + 4 <= 12 (n + 1)$

If $n = 1$….

$5(1 +1) + 4 = 14$
$12(1+1) = 12(2) = 24$

$14 <= 24$

Thus, $T(n) <= c * f(n)$ and $T(n+1) <= c * f(n+1)$

ANSWER: Therefore, the mathematical proof by induction shows this algorithms Big 0 Time Complexity is $0(n^2)$

<u>Alternate Algorithm Time Complexity</u>

$10n^2 + 10n + 2$ looks to be $0(n^2)$, but proof is required….

“If $F(x)$ is a real-valued function, then the limit of F as x approaches infinity is L,

Lim x approaches infinity, $F(x) = L$

means that for any $\varepsilon > 0$, there exists k such that $|F(x) - L| < \varepsilon$ whenever $x > k$.”

$T(n) = 10n^2 + 10n + 2 = 0(n^2)$ using the limit definition….

Lim n approaches infinity, $T(n)/f(n)$

$10n^2 + 10n + 2 / n^2 =$

$\text{Lim } 10n^2 / n^2 + \text{lim } 10n/n^2 + \text{lim } 2/n^2 =$

$10 + 10/n^2 + 2/n^2 =$

$10 + 0 = 10$

10 is not negative and constant

Thus, $10n^2 + 10n + 2$ is $0(n^2)$

ANSWER: Therefore, the mathematical proof by limits shows this algorithms Big 0 Time Complexity is $0(n^2)$