CPSC 335 Project 1

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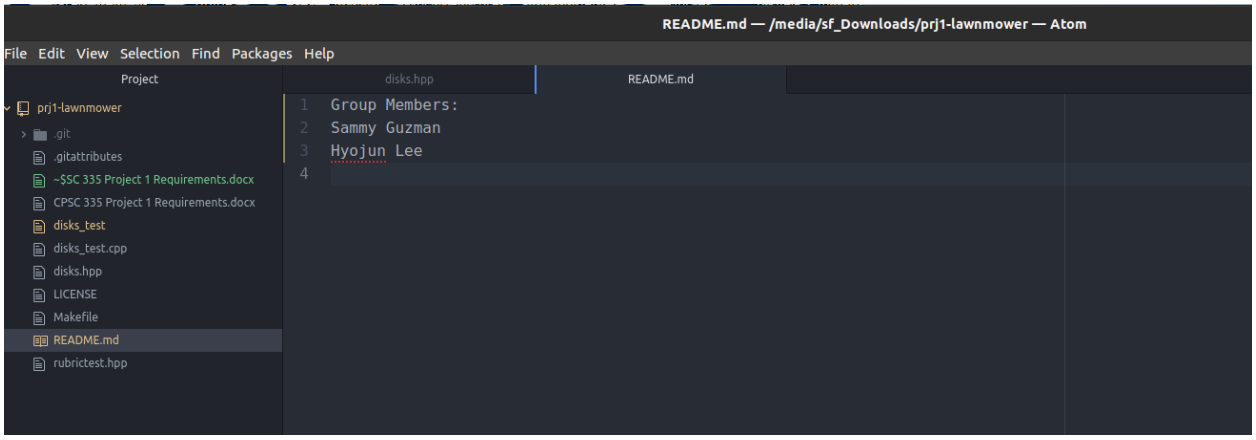
Git link:https://github.com/defianttz/prj1-lawnmower/tree/main




```
student@tuffix-vm:/media/sf_Downloads/prj1-lawnmower$ make
g++ -std=c++11 -Wall disks_test.cpp -o disks_test
./disks_test
disk_state still works: passed, score 1/1
sorted_disks still works: passed, score 1/1
disk_state::is_initialized: passed, score 3/3
disk_state::is_sorted: passed, score 3/3
alternate, n=4: passed, score 1/1
alternate, n=3: passed, score 1/1
alternate, other values: passed, score 1/1
lawnmower, n=4: passed, score 1/1
lawnmower, n=3: passed, score 1/1
lawnmower, other values: passed, score 1/1
TOTAL SCORE = 14 / 14

student@tuffix-vm:/media/sf_Downloads/prj1-lawnmower$ S
```

The lawnmower algorithm

Algorithm Design:

Pseudo Code

```
for i = 0 to n/2 do

   for j = 0 to 2n-1 do
      if list[j] > list[j+1]
         swap
      end
   end for

    for j = 2n-1 to 0 do
      if list[j] <  list[j-1]
   swap
      end
   end for
end for
```

Step Count

```
                                  // SC outer loop =
for i = 0 to n/2 do                  // (n+1)/2 times
                                     // SC forward loop
   for j = 0 to 2n-1 do               // 2n times
      if list[j] > list[j+1]          // 1 TU
         Swap                         // 3 TU
         m++                          // 1 TU
      end
   end

                                    // SC reverse loop
   for j = 2n-1 to 0 do             // 2n times
      if list[j] <  list[j-1]          // 1 TU
         Swap                         // 3 TU
         m++                          // 1 TU
      end
   end
end
```

$$S.C_{forward} = 2n(1 + max(4,0))$$
$$= 2n(1 + 4)$$
$$= 2n(5)$$
$$= 10n$$
$$S.C_{reverse} = 2n(1 + max(4,0))$$
$$= 2n(1 + 4)$$
$$= 2n(5)$$
$$= 10n$$

$$S.C. = S.C_{outer} * (S.C_{forward} + S.C_{reverse})$$
$$= (\frac{n+1}{2})(10n + 10n)$$
$$= (\frac{n+1}{2})(20n)$$
$$= (\frac{20n^2+20n}{2})$$
$$= (10n^2 + 10n)$$

Mathematical Analysis

-Big-O efficiency class: O(n^2)

-Definition:

$10n^2 + 10n \in O(n^2)$

$10n^2 + 10n \leq C \cdot n^2$

$C = 10 + 10 = 20, no = 1$

$10n^2 + 10n \leq 20n^2$

$10 + 10 \leq 20$

$20 \leq 20 \rightarrow true$

By Definition, we can say that $10n^2 + 10n \in O(n^2)$.

Limit Theorem:

Prove that $10n^2 + 10n \in O(n^2)$ using the limit theorem

$$lim_{n\to\infty} \frac{10n^2+10n}{n^2}$$

$$= lim_{n\to\infty} \frac{10n^2}{n^2} + \frac{10n}{n^2}$$

$$= lim_{n\to\infty} 10 + lim_{n\to\infty} \frac{10}{n}$$

$$lim_{n\to\infty} = 10 \geq 0,$$

By Limit theorem, we can say that $10n^2 + 10n \in O(n^2)$.

The Alternating Disk Algorithm

Algorithm Design:

Pseudo Code

```
For i = 0 to N step
   if (i % 2 == 0)
      for j = 0 to N-1 step + 2
         if (list[j]  > list[j + 1])
            Swap disks
            m++;
         end if
      end for
   else do
      for j = 1 to N-2 step + 2
         if (list[j]  > list[j + 1])
```

```
            Swap disks
            m++;
         end if
      end for
   end if
end for
```

Step Count

```
For i = 0 to N                    // (n-0)+1/1= n+1
   if (i % 2 == 0)                      // 2 TU
      for j = 0 to N-1 step + 2         // (n-1-0+1)/2 = n/2
         if (list[j]  > list[j + 1])    // 1 TU
            Swap disks                  // 3 TU
            M++;                        // 1 TU
         end
      end
   else
      for j = 1 to N-2 step + 2         // ((n-2)-1+1)/2= n-2/2
         if (list[j]  > list[j + 1])    // 1 TU
            Swap disks                  // 3 TU
            M++;                        // 1 TU
         end
       end
  End
```

$$S.C. = S.C_{outer} * (S.C_{if\ block})$$

$$S.C_{outer\ loop} = n + 1$$

$$S.C_{if\ block} = 2 + max(S.C_{even\ loop}, S.C_{odd\ loop})$$

$$S.C_{even\ loop} = \frac{n}{2}(1 + max(4, 0))$$

$$= \frac{n}{2}(1 + 4)$$

$$= \frac{n}{2}(5)$$

$$= \frac{5n}{2}$$

$$S.C_{odd\ loop} = \frac{n-2}{2}(1 + max(4, 0))$$
$$= \frac{n-2}{2}(1 + 4)$$
$$= \frac{n-2}{2}(5)$$
$$= \frac{5n-10}{2}$$

$$S.C = (n + 1)(2 + max(\frac{5n}{2}, \frac{5n-10}{2}))$$

$$= (n + 1)(2 + \frac{5n}{2})$$
$$= \frac{5n^2}{2} + \frac{5n}{2} + 2n + 2$$
$$= \frac{5n^2}{2} + \frac{9n}{2} + 2$$

Mathematical Analysis

-Big-O efficiency class:

-Definition:

$$\frac{5n^2}{2} + \frac{9n}{2} + 2 \in O(n^2)$$
$$\frac{5n^2}{2} + \frac{9n}{2} + 2 \leq C \cdot n^2$$

$$C = \frac{5}{2} + \frac{9}{2} + 2 = 9,\ no = 1$$
$$\frac{5n^2}{2} + \frac{9n}{2} + 2 \leq 9n^2$$
$$\frac{5}{2} + \frac{9}{2} + 2 \leq 9$$
$$9 \leq 9 \rightarrow true$$

By definition, we can say that $\frac{5n^2}{2} + \frac{9n}{2} + 2 \in O(n^2)$.

Limit Theorem:

Prove that $\frac{5n^2}{2} + \frac{9n}{2} + 2 \in O(n^2)$ using the limit theorem

$$lim_{n\to\infty} \frac{\frac{5}{2}n^2 + \frac{9}{2}n + 2}{n^2}$$

$$= lim_{n\to\infty} \frac{\frac{5}{2}n^2}{n^2} + \frac{\frac{9}{2}n}{n^2} + \frac{2}{n^2}$$

$$= lim_{n\to\infty} \frac{5}{2} + lim_{n\to\infty} \frac{\frac{9}{2}}{n} + lim_{n\to\infty} \frac{2}{n^2}$$

$$= \frac{5}{2} + 0 + 0$$

$$= \frac{5}{2}$$

$lim_{n\to\infty} = \frac{5}{2} \geq 0,$

By Limit Theorem, we can say that $\frac{5n^2}{2} + \frac{9n}{2} + 2 \in O(n^2)$.