CPSC 335 - Algorithm Engineering
Project 2: Greedy versus Exhaustive

Malka Ariel Lazerson
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Instructor: Doina Bein

Table of Contents

Names, CSUF Email, and Intent

Name: Malka Ariel Lazerson

CSUF Email: mlazerson@csu.fullerton.edu

Intent: This document is intended to be one part of a submission for Project 2: Greedy versus Exhaustive. This document contains….

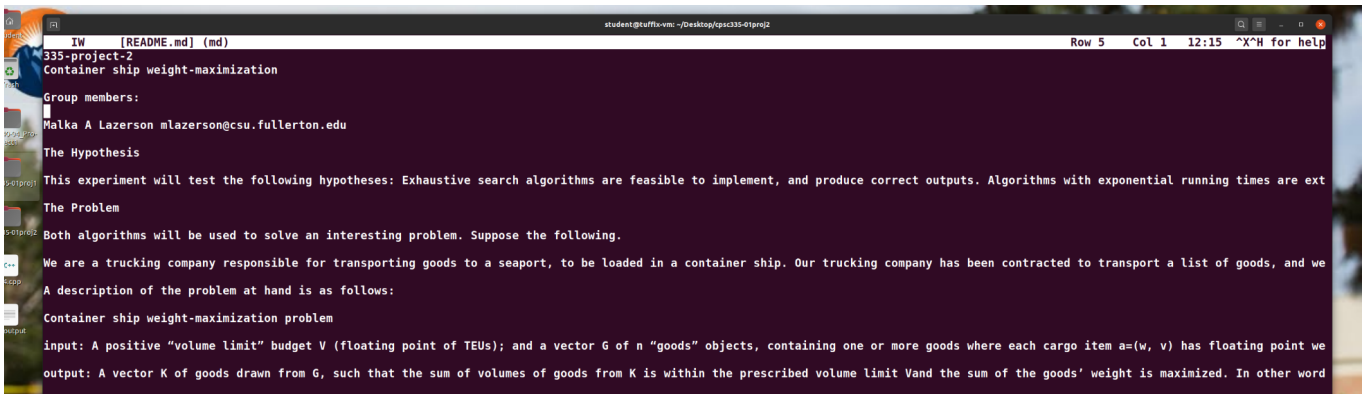
1. Names, CSUF-supplied email address(es), and an indication that the submission is for project 2.
2. Proof of code compilation and successful execution
2. Two scatter plots
3. Answers to the following questions, using complete sentences.

Questions….

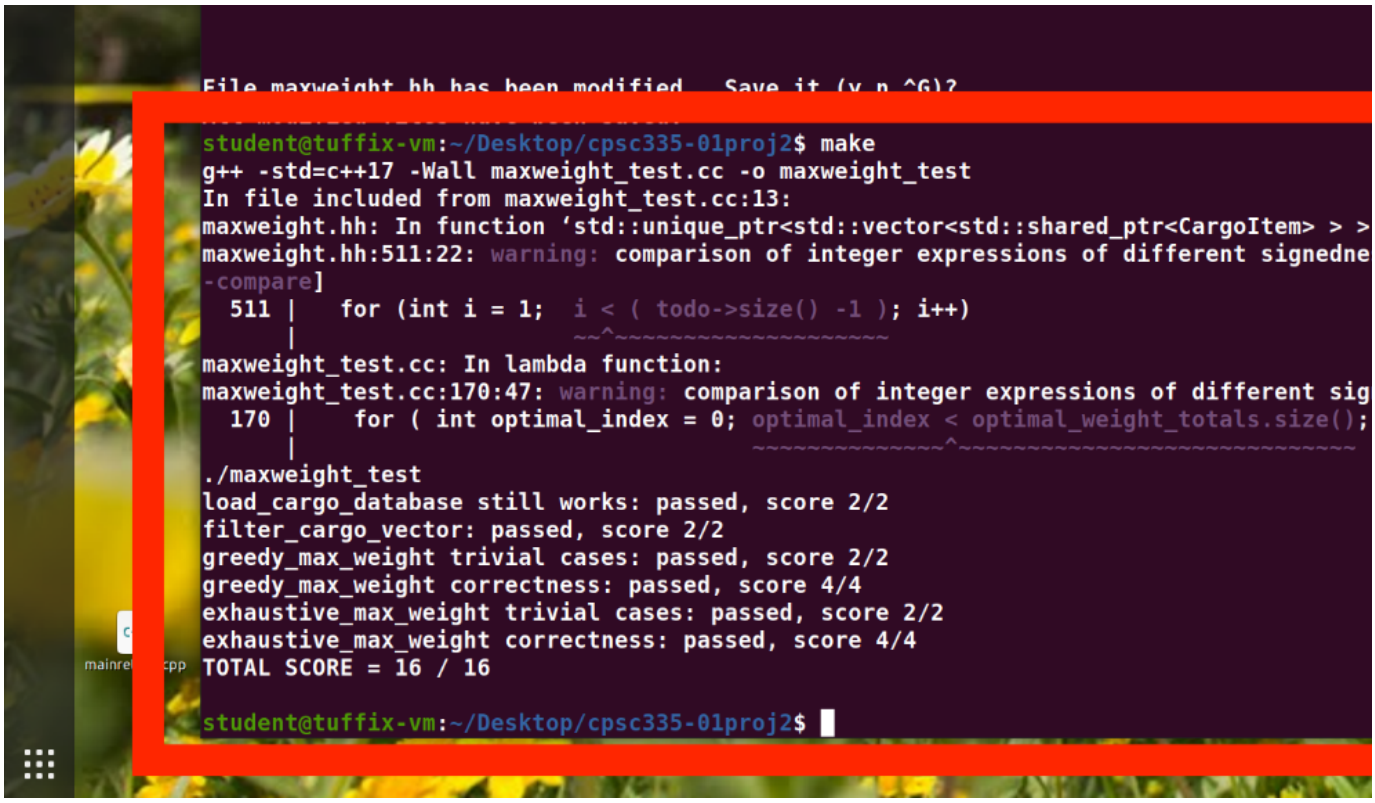
Is there a noticeable difference in the performance of the two algorithms? Which is faster, and by how much? Does this surprise you?
Are your empirical analyses consistent with your mathematical analyses? Justify your answer.
Is this evidence consistent or inconsistent with hypothesis 1? Justify your answer.
Is this evidence consistent or inconsistent with hypothesis 2? Justify your answer.

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

ReadMe.md Screenshot



Code Compilation and Execution



Empirical Data

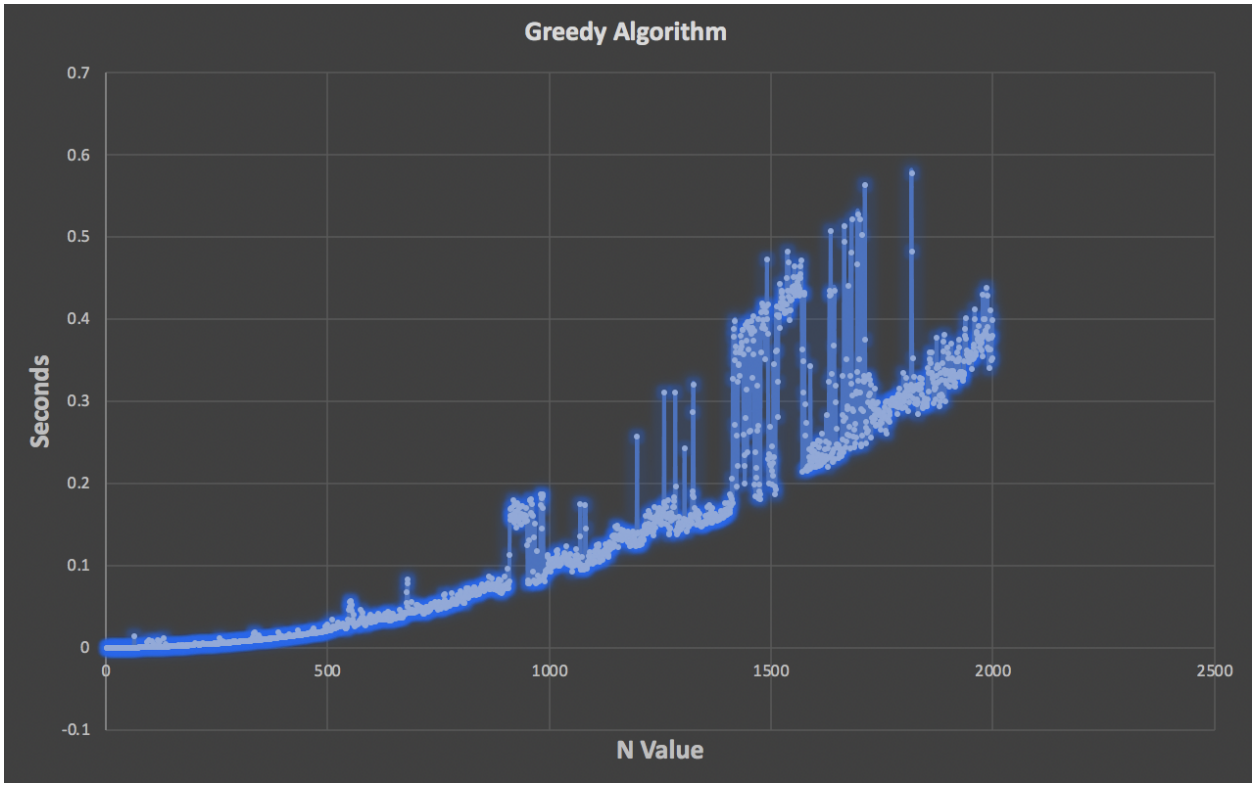
Greedy (smaller sample due to the csv file containing 2000 records)

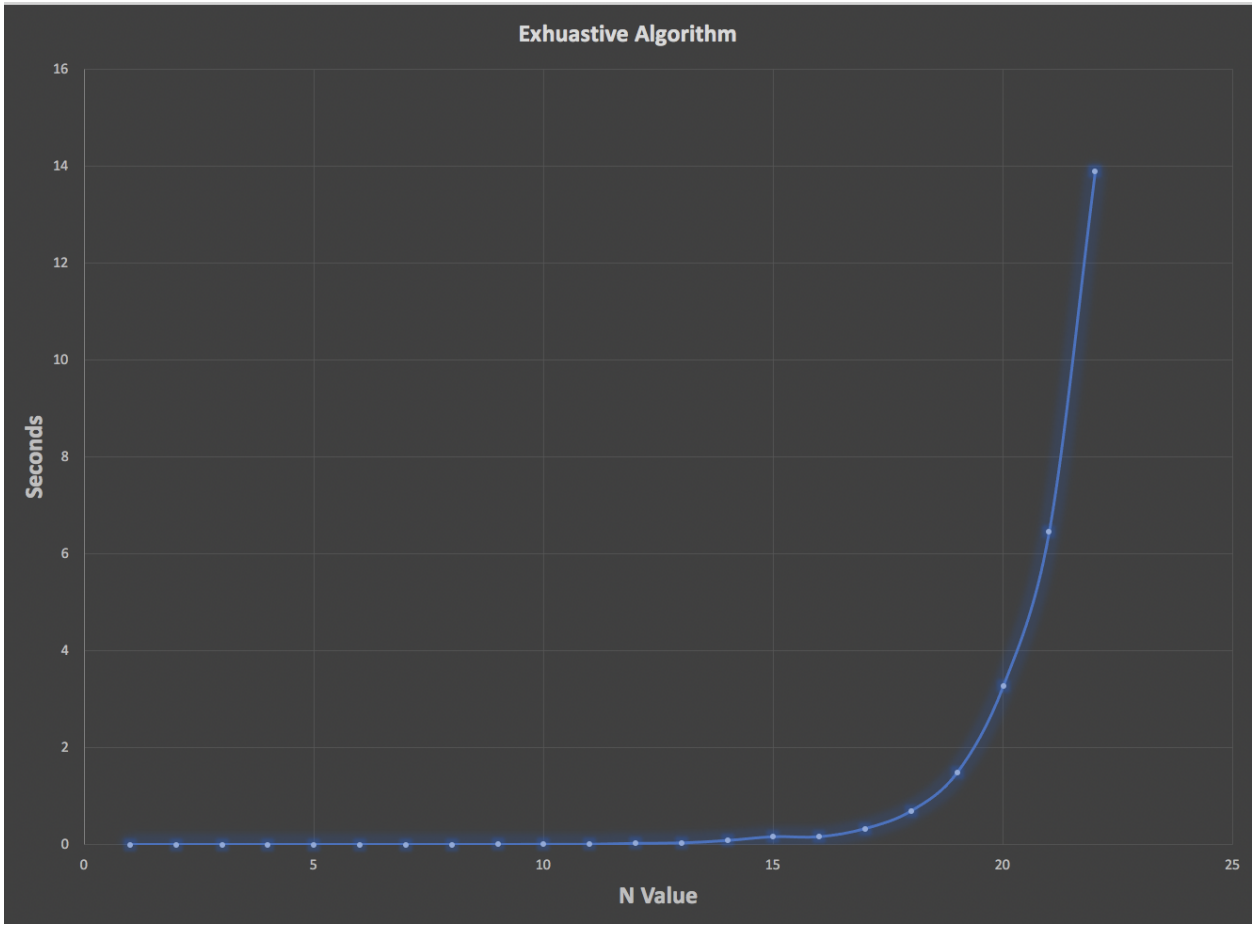
n	seconds
1	5.295E-06
2	2.094E-06
3	2.219E-06
4	3.203E-06
5	3.886E-06
6	4.906E-06
7	6.245E-06
8	7.596E-06
9	9.311E-06
10	1.082E-05
11	1.315E-05
12	1.514E-05
13	1.693E-05
14	1.918E-05
15	2.158E-05
16	2.458E-05
17	2.685E-05
18	2.993E-05
19	3.337E-05
20	3.643E-05
21	3.959E-05
22	4.4E-05
23	4.695E-05
24	5.028E-05
25	5.525E-05
26	5.905E-05
27	6.343E-05
28	6.826E-05
29	0.0001095
30	7.918E-05

Exhaustive

n	seconds
1	1.1157E-05
2	3.681E-06
3	7.081E-06
4	1.5916E-05
5	3.4214E-05
6	7.4252E-05
7	0.00016354
8	0.00035618
9	0.00079641
10	0.00165374
11	0.00386692
12	0.02305299
13	0.03190128
14	0.08324177
15	0.16080957
16	0.1602824
17	0.32855243
18	0.6942229
19	1.48594501
20	3.26622518
21	6.45566497
22	13.8857117

Scatter Plots





Mathematical Analysis

This section includes pseudocode, the step count, and Big O Time Complexity

Filter Cargo Vector

Step Count.....

empty ValidCargo // 1
itemCount = 0; // 1

for i to N in goods do: // N

if item->weight() >= min weight and item->weight() <= max weight // 2

```
        if itemCount < total_size // 1

          add to ValidCargo // 1
                itemCount++ // 1

        else
          break out of for loop // 1

 End for

 return ValidCargo // 1
```

Calculation.....

1 + 1 + n * (2 + 1 + 1 + 1 + 1) + 1 =

2 + n * (6) + 1 =

3 + 6n

Filter Cargo Vector step count is 3 + 6n

Proof.....

Lim as n -> infinity 3 + 6n

Lim as n -> infinity 3 + 6n / n

Lim as n -> infinity 3/n + 6

Apply limit: 3/n = 0, and 0 + 6 = 6

6 >= 1 , so our proof is successful

Filter Cargo Vector is O(n) Time Complexity

Greedy

Step Count.....

```
empty result // 1
 empty todo = goods // 1
 result_volume = 0 // 1
 v = 0 // 1

    while todo is not empty do: // n (log n)

        // max item index tracker
        maxIndex = 0 // 1

          // Find a good a of w/v ratio
          for i = 1 to  todo->size() -1 do: // N - 1

             if item weight/volume ratio at i > item weight/volume ratio at maxIndex // 2
               maxIndex = i // 1

           End for

          v = maxIndex->volume() // 1

           //add to greedy solution if v <= V
           if result_volume + v <= V // 2
              add maxIndex to result // 1
              result_volume += v // 1

          //remove from todo so as not to compare this item again
          remove maxIndex from todo // 1


    End while

    return result // 1
```

Calculation.....

$4 + n(\log n) * (1 + (n - 1)*(1 + 2) + 1 + 2 + 1 + 1 + 1) + 1 =$

$4 + n(\log n) * ((3n - 3) + 7) + 1 =$

$4 + n(\log n) * ((3n - 4) + 1 =$

5 + 3n(log(4) n) =

Greedy Algorithm step count is 5 + 3n(log(4) n)

Proof.....

Lim as n -> infinity 5 + 3n(log(4) n)

Lim as n -> infinity 5 + 3n(log(4) n) / n (log (4) n)

Lim as n -> infinity (1/n) / (1/n) = 1

(1/n) / (1/n) = 1, 1 > 0

Exhaustive algorithm is O(n log(n))

Exhaustive

Step Count.....

sum vector step count.....

```
total_volume = total_weight = 0; // 1

        for (auto& item : goods) // N

                total_volume += item->volume(); // 1
                total_weight += item->weight(); // 1
```

step count for sum function is 1 + n * (1 +1) = 1 + 2n = o(n) time

Step count for greedy.....

```
empty bestCargo // 1
candidateTotalWgt = 0 // 1
candidateTotalVol = 0 // 1
bestTotalWgt = 0 // 1
```

```
bestTotalVol = 0 // 1
//size of goods
size_t n = size of goods // 1

 //for bitwise method, vector must be <= 64 in size
 if n >= 64 // 1
   overflow and exit // 1


 for (uint64_t b = 0; b < pow(2, n); b++) do: // (2^n) + 1

     empty candidate vector // 1

    for (uint64_t i = 0; i < n; i++) do: // n + 1

        if (((b >> i) & 1) == 1) // 3

            add i to candidate vector // 1
     End for

    // calculate totals of candidate and best
    sum of candidate // 1 + 2n
    sum of current best // 1 + 2n

    //if within budget and has greater total time than current best
    if candidateTotalVol <= total_volume // 1

       if bestCargo->empty()  OR candidateTotalWgt > bestTotalWgt // 3

           bestCargo vector = candidate vector // 1

   End for

 return bestCargo // 1
```

Calculation.....

8 + ((2^n + 1) * (6 + (2n+1) + (2n+1) + 5)

8 + ((2^n + 1) * (4n + 2 + 11) =

8 + ((2^n + 1) * (4n + 13) =

8 + (2^n)(4n) + (2^n)(13) + 4n + 13 =

(2^n)(4n) + (2^n)(16) + 4n + 21

Greedy Algorithm step count is (2^n)(4n) + (2^n)(16) + 4n + 21

Proof.....

Let t = (2^n)(4n) + (2^n)(16) + 4n + 21 be in O (2^n)

8 + 32 + 4 + 21 = 65, let c = 65, let n = 1

Let (2^n)(4n) + (2^n)(16) + 4n + 21 > n * 2^n

65 * (2^n)(4n) + (2^n)(16) + 4n + 21

130 - 8 - 32 - 4 - 21 > 0, 65 > 0

Exhaustive algorithm is O(n * 2^n)

Questions

Is there a noticeable difference in the performance of the two algorithms? Which is faster, and by how much? Does this surprise you?

Yes, after the N time grows large enough, there is a noticeable difference. The exhaustive algorithm is much slower than the greedy algorithm. This does not surprise me because exhaustive is O(2^n * n), and greedy is O(n log(n)).

Are your empirical analyses consistent with your mathematical analyses? Justify your answer.

The mathematical evidence and the empirical analysis align. The exhaustive graph shows a larger jump in time than the greedy algorithm.

Is this evidence consistent or inconsistent with hypothesis 1? Justify your answer.

The evidence is consistent with hypothesis 1, as the exhaustive algorithm will produce the best output in more time. Accuracy is important, even at the expense of time.

Is this evidence consistent or inconsistent with hypothesis 2? Justify your answer.

The evidence also supports hypothesis 2, because the exhaustive algorithm of exponential time is extremely slow. It is definitely impractical to use in a real world setting.