CSC2023: Algorithm Design and Analysis Assignment 2: Glass Cutting Problem

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# Correctness testing

I have tested both algorithms for 10 cases:

Test case 1: "random" test

Test case 2: "random" test check if shape will be placed after another shape in a shelf if there is enough space, should place all shapes in 1 shelf

Test case 3: testing if shape will be placed in the shelf if there is enough space after it is being rotated

Test case 4: testing if shape will be placed on a new shelf (not rotated)

Test case 5: testing if shape will be placed on a new shelf after being rotated

Test case 6: The total height of all shelves in a sheet does not exceed H

Test case 7: check if number of shapes placed on a sheet cannot exceed L (20 shapes per Sheet)

Test case 8: check if the item will be added at the first available spot (First Fit)

Test case 8: check if the item will be added at/after the last used sheet (NEXTFIT)

Here I only place the tests for First and Next Fit algorithms that my program outputted. I have tested them with values that will satisfy each test if the algorithm is right of course.

There are 8 tests for each algorithm that test its correctness by outputting the expected values.

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\*\*\*\*\*\*\*\*\*\*\* Correctness testing \*\*\*\*\*\*\*\*\*\*\*\*\*

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Results for test No 1 is:

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First Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 243, shelf height is 140

Shape 1 width 238 and has height 140

Shape 2 width 5 and has height 40

Shelf 2 has 1 shape inside. The used shelf width is 251, shelf height is 65

Shape 1 width 251 and has height 65

Number of shapes 3

Sheet contains 2 shelves

Shelf 1 has 1 shape inside. The used shelf width is 209, shelf height is 73

Shape 1 width 209 and has height 73

Shelf 2 has 1 shape inside. The used shelf width is 264, shelf height is 76

Shape 1 width 264 and has height 76

Number of shapes 2

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Next Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 243, shelf height is 140

Shape 1 width 238 and has height 140

Shape 2 width 5 and has height 40

Shelf 2 has 1 shape inside. The used shelf width is 251, shelf height is 65

Shape 1 width 251 and has height 65

Number of shapes 3

Sheet contains 2 shelves

Shelf 1 has 1 shape inside. The used shelf width is 209, shelf height is 73

Shape 1 width 209 and has height 73

Shelf 2 has 1 shape inside. The used shelf width is 264, shelf height is 76

Shape 1 width 264 and has height 76

Number of shapes 2

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Results for test No 2 is:

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First Fit

Sheet contains 1 shelves

Shelf 1 has 5 shape inside. The used shelf width is 207, shelf height is 200

Shape 1 width 20 and has height 200

Shape 2 width 40 and has height 150

Shape 3 width 30 and has height 149

Shape 4 width 17 and has height 111

Shape 5 width 100 and has height 200

Number of shapes 5

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Next Fit

Sheet contains 1 shelves

Shelf 1 has 5 shape inside. The used shelf width is 207, shelf height is 200

Shape 1 width 20 and has height 200

Shape 2 width 40 and has height 150

Shape 3 width 30 and has height 149

Shape 4 width 17 and has height 111

Shape 5 width 100 and has height 200

Number of shapes 5

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Results for test No 3 is:

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First Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 260, shelf height is 150

Shape 1 width 100 and has height 150

Shape 2 width 160 and has height 140

Shelf 2 has 2 shape inside. The used shelf width is 300, shelf height is 100

Shape 1 width 150 and has height 100

Shape 2 width 150 and has height 100

Number of shapes 4

Sheet contains 1 shelves

Shelf 1 has 2 shape inside. The used shelf width is 250, shelf height is 220

Shape 1 width 100 and has height 220

Shape 2 width 150 and has height 210

Number of shapes 2

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Next Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 260, shelf height is 150

Shape 1 width 100 and has height 150

Shape 2 width 160 and has height 140

Shelf 2 has 2 shape inside. The used shelf width is 300, shelf height is 100

Shape 1 width 150 and has height 100

Shape 2 width 150 and has height 100

Number of shapes 4

Sheet contains 1 shelves

Shelf 1 has 2 shape inside. The used shelf width is 250, shelf height is 220

Shape 1 width 100 and has height 220

Shape 2 width 150 and has height 210

Number of shapes 2

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Results for test No 4 is:

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First Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 260, shelf height is 150

Shape 1 width 100 and has height 150

Shape 2 width 160 and has height 140

Shelf 2 has 1 shape inside. The used shelf width is 150, shelf height is 100

Shape 1 width 150 and has height 100

Number of shapes 3

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Next Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 260, shelf height is 150

Shape 1 width 100 and has height 150

Shape 2 width 160 and has height 140

Shelf 2 has 1 shape inside. The used shelf width is 150, shelf height is 100

Shape 1 width 150 and has height 100

Number of shapes 3

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Results for test No 5 is:

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First Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 260, shelf height is 150

Shape 1 width 100 and has height 150

Shape 2 width 160 and has height 140

Shelf 2 has 1 shape inside. The used shelf width is 200, shelf height is 100

Shape 1 width 200 and has height 100

Number of shapes 3

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Next Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 260, shelf height is 150

Shape 1 width 100 and has height 150

Shape 2 width 160 and has height 140

Shelf 2 has 1 shape inside. The used shelf width is 200, shelf height is 100

Shape 1 width 200 and has height 100

Number of shapes 3

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Results for test No 6 is:

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First Fit

Sheet contains 2 shelves

Shelf 1 has 2 shape inside. The used shelf width is 260, shelf height is 150

Shape 1 width 100 and has height 150

Shape 2 width 160 and has height 140

Shelf 2 has 1 shape inside. The used shelf width is 100, shelf height is 100

Shape 1 width 100 and has height 100

Number of shapes 3

Sheet contains 1 shelves

Shelf 1 has 1 shape inside. The used shelf width is 150, shelf height is 151

Shape 1 width 150 and has height 151

Number of shapes 1

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Next Fit

Sheet contains 1 shelves

Shelf 1 has 2 shape inside. The used shelf width is 260, shelf height is 150

Shape 1 width 100 and has height 150

Shape 2 width 160 and has height 140

Number of shapes 2

Sheet contains 1 shelves

Shelf 1 has 2 shape inside. The used shelf width is 250, shelf height is 151

Shape 1 width 150 and has height 151

Shape 2 width 100 and has height 100

Number of shapes 2

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Results for test No 7 is:

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First Fit

Sheet contains 1 shelves

Shelf 1 has 20 shape inside. The used shelf width is 20, shelf height is 1

Shape 1 width 1 and has height 1

Shape 2 width 1 and has height 1

Shape 3 width 1 and has height 1

Shape 4 width 1 and has height 1

Shape 5 width 1 and has height 1

Shape 6 width 1 and has height 1

Shape 7 width 1 and has height 1

Shape 8 width 1 and has height 1

Shape 9 width 1 and has height 1

Shape 10 width 1 and has height 1

Shape 11 width 1 and has height 1

Shape 12 width 1 and has height 1

Shape 13 width 1 and has height 1

Shape 14 width 1 and has height 1

Shape 15 width 1 and has height 1

Shape 16 width 1 and has height 1

Shape 17 width 1 and has height 1

Shape 18 width 1 and has height 1

Shape 19 width 1 and has height 1

Shape 20 width 1 and has height 1

Number of shapes 20

Sheet contains 1 shelves

Shelf 1 has 5 shape inside. The used shelf width is 5, shelf height is 1

Shape 1 width 1 and has height 1

Shape 2 width 1 and has height 1

Shape 3 width 1 and has height 1

Shape 4 width 1 and has height 1

Shape 5 width 1 and has height 1

Number of shapes 5

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Next Fit

Sheet contains 1 shelves

Shelf 1 has 20 shape inside. The used shelf width is 20, shelf height is 1

Shape 1 width 1 and has height 1

Shape 2 width 1 and has height 1

Shape 3 width 1 and has height 1

Shape 4 width 1 and has height 1

Shape 5 width 1 and has height 1

Shape 6 width 1 and has height 1

Shape 7 width 1 and has height 1

Shape 8 width 1 and has height 1

Shape 9 width 1 and has height 1

Shape 10 width 1 and has height 1

Shape 11 width 1 and has height 1

Shape 12 width 1 and has height 1

Shape 13 width 1 and has height 1

Shape 14 width 1 and has height 1

Shape 15 width 1 and has height 1

Shape 16 width 1 and has height 1

Shape 17 width 1 and has height 1

Shape 18 width 1 and has height 1

Shape 19 width 1 and has height 1

Shape 20 width 1 and has height 1

Number of shapes 20

Sheet contains 1 shelves

Shelf 1 has 5 shape inside. The used shelf width is 5, shelf height is 1

Shape 1 width 1 and has height 1

Shape 2 width 1 and has height 1

Shape 3 width 1 and has height 1

Shape 4 width 1 and has height 1

Shape 5 width 1 and has height 1

Number of shapes 5

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Results for test No 8 is:

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First Fit

Sheet contains 2 shelves

Shelf 1 has 5 shape inside. The used shelf width is 5, shelf height is 1

Shape 1 width 1 and has height 1

Shape 2 width 1 and has height 1

Shape 3 width 1 and has height 1

Shape 4 width 1 and has height 1

Shape 5 width 1 and has height 1

Shelf 2 has 1 shape inside. The used shelf width is 300, shelf height is 200

Shape 1 width 300 and has height 200

Number of shapes 6

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Next Fit

Sheet contains 1 shelves

Shelf 1 has 2 shape inside. The used shelf width is 2, shelf height is 1

Shape 1 width 1 and has height 1

Shape 2 width 1 and has height 1

Number of shapes 2

Sheet contains 1 shelves

Shelf 1 has 1 shape inside. The used shelf width is 300, shelf height is 250

Shape 1 width 300 and has height 250

Number of shapes 1

Sheet contains 2 shelves

Shelf 1 has 1 shape inside. The used shelf width is 298, shelf height is 1

Shape 1 width 298 and has height 1

Shelf 2 has 2 shape inside. The used shelf width is 4, shelf height is 1

Shape 1 width 3 and has height 1

Shape 2 width 1 and has height 1

Number of shapes 3

For the tests I have used values that match each case you can try all the tests for yourself if you want, I have said how in the program.

# 2.The tabulated results of the overall comparisons for Tasks 5+coments.

Here I have pasted part of the testing of my program. I copied the results that my program outputs in a table like form. You can test it for yourself and adjust the tests, repetitions and shapes to your liking.

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\*\*\*\*\*\*\*\*\*\*\* Performance analysis \*\*\*\*\*\*\*\*\*\*\*\*\*\*

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First Fit and Next Fit

For Test No 1 that had 5 repetitions for 10000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 1.25626712 sec final Time: 1.08960846 sec

Sheets: 2768 Sheets: 2794

For Test No 2 that had 5 repetitions for 20000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 6.2083259 sec final Time: 5.9249519 sec

Sheets: 8258 Sheets: 8283

For Test No 3 that had 5 repetitions for 30000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 17.58195844 sec final Time: 17.63298138 sec

Sheets: 16437 Sheets: 16504

For Test No 4 that had 5 repetitions for 40000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 41.22989928 sec final Time: 42.17884188 sec

Sheets: 27325 Sheets: 27417

For Test No 5 that had 5 repetitions for 50000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 94.47892952 sec final Time: 96.27212342 sec

Sheets: 40937 Sheets: 40966

Average times and Sheets for the whole run:

Final average time of First Fit: 18.895785904

Final average time of Next Fit: 19.254424684

Sheets First Fit: 8187 Sheets Next Fit: 8193

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\*\*\*\*\*\*\*\*\*\*\* Performance analysis \*\*\*\*\*\*\*\*\*\*\*\*\*\*

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First Fit and Next Fit

For Test No 1 that had 5 repetitions for 10000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 2.19457736 sec final Time: 1.96194104 sec

Sheets: 2793 Sheets: 2793

For Test No 2 that had 5 repetitions for 20000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 9.62679252 sec final Time: 9.35136872 sec

Sheets: 8304 Sheets: 8304

For Test No 3 that had 5 repetitions for 30000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 31.937174 sec final Time: 33.06840632 sec

Sheets: 16500 Sheets: 16500

For Test No 4 that had 5 repetitions for 40000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 83.56436812 sec final Time: 84.78174006 sec

Sheets: 27417 Sheets: 27417

For Test No 5 that had 5 repetitions for 50000 shapes.

First Fit gave this result: and Next Fit gave this result:

final Time: 154.36979694 sec final Time: 153.39375096 sec

Sheets: 41008 Sheets: 41008

Average times and Sheets for the whole run:

Final average time of First Fit: 30.873959387999996

Final average time of Next Fit: 30.678750192000003

Sheets First Fit: 8201 Sheets Next Fit: 8201

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From the tests that I did for first and next fit I can say that in my opinion next fit is slightly faster, but it also uses more sheets that first fit.

All and all during my tests with random values both algorithms show very close results, but I think that in terms of time performance of the algorithm next fit beats first fit, but in terms of sheets used most of the times first fit uses less. Also, for the performance of the algorithms is important the input that in our case is random, but if the input consists of mainly larger shapes Next fit would do a better job than first fit, because it is more likely a new sheet to be created and next fit would skip the checks for all the previous sheets and create a new shape faster. Overall for time performance next fit is better, but first fit has the chance to use less sheets, so we can conclude that the more time efficient algorithm is next fit, but in terms of saving space, materials and sheets first fit might be better.

# 3.The tabulated results of the overall comparisons for Tasks 6 comments.

Those are the results for 10 thousand shapes:

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\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* Sorted Test \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

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Unsorted and Sorted In increased order First Fit

Sorted Unsorted

Sheets: 3475 Sheets: 2763

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Unsorted and Sorted In decreasing order First Fit

Sorted Unsorted

Sheets: 2702 Sheets: 2763

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Unsorted and Sorted In increased order NEXT Fit

Sorted Unsorted

Sheets: 4185 Sheets: 4665

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Unsorted and Sorted In decreasing order NEXT Fit

Sorted Unsorted

Sheets: 4195 Sheets: 4665

We can clearly see that Next fit always uses more sheets that first fit. It also appears that first fit uses the least sheets when sorted in decreasing order and the most when sorted in increasing order. On the other hand, next fit gives significantly better results in terms of sheet usage when it is sorted.

This trend continues with the test of 50 thousand shapes that you can see below.

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\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* Sorted Test \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

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Unsorted and Sorted In increased order First Fit

Sorted Unsorted

Sheets: 16981 Sheets: 13496

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Unsorted and Sorted In decreasing order First Fit

Sorted Unsorted

Sheets: 13382 Sheets: 13496

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Unsorted and Sorted In increased order NEXT Fit

Sorted Unsorted

Sheets: 20978 Sheets: 23266

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Unsorted and Sorted In decreasing order NEXT Fit

Sorted Unsorted

Sheets: 20976 Sheets: 23266

So, in conclusion It is worth it to sort the array before using next fit, because it makes a big difference. Although the difference in sheets used is not that big it is still ok to sort first fit’s shapes in decreasing order as it assures that you would have the best outcome.

I would recommend using an algorithm like quicksort and comparing the elements by either height or weight. It doesn’t really matter which one you pick, because the shape will eventually get rotated and placed in the same spot. In my testing I have compared the shapes by height using the quicksort and bubble sort algorithm to sort the list and I found that quick sort has the best performance.