AlgoInvest&Trade
Project 7 - Solve Problems Using Algorithms in Python

Big-O Complexity Chart

| Horrible | Bad | Fair | Good | Excellent |

O(n!) O(2^n) O(n^2)

O(n log n)

O(n)

O(log n), O(1)

Operations

Elements
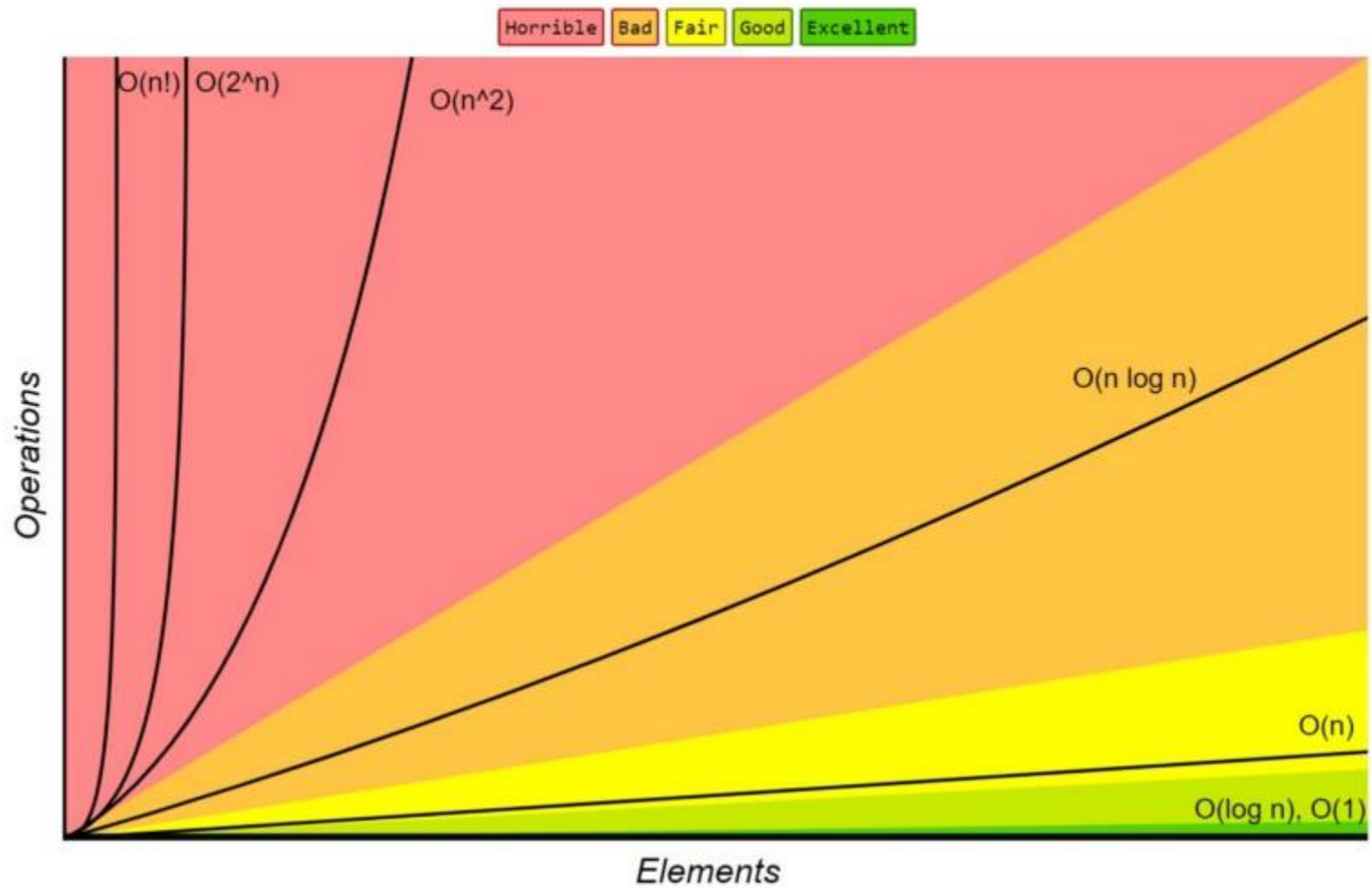
Brute force method

Analysis:

Advantage:
- perfect solution for processing a small number of items
- generates and checks all possible combinations to find the perfect solution

Disadvantage:
- complexity is O(2^n) - can't be scaled very far, grows exponentially
- if there are "n" items to choose from, then there will be 2^n possible combinations that need to be checked
- needs more memory to store all possible results
- can only be used for small instances, otherwise it will be very time consuming

| Amount of shares (n)	Possible combinations (2^n)
0	1
1	2
2	4
4	16
10	1024
15	32768
20	1048576

More elements need exponentially more operations and therefore more time.

Greedy method

Pseudo code:

function greedy(available shares, available budget, shares sorted by):
    initialize share package with empty array
    initialize share package prize with 0
    initialize share package profit with 0

    while available shares are not empty
        take first share out of available shares
        if share price + share package prize is lower or equal the available budget
            append share to share package
            add share prize to share package prize
            add share profit to share package profit
    return share package, share package prize, share package profit
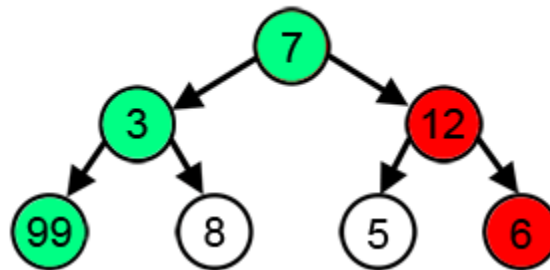
complexity is O(n log n) due to sorting the available data

Advantage:
- very fast and does not use a lot of memory

Disadvantage:
- result is not optimal and can easily miss better options

Dynamic programming method

Pseudo code:

```
function dynamic(available shares, available budget):
        initialize share package with empty array
        initialize share package prize with 0
        initialize share package profit with 0
        initialize amount of shares with number of available shares
        initialize total shares price with empty array
        initialize total profit with empty array

        for every share in available shares:
                append share price to total shares price
                append share profit to total shares profit

        # create the 2-dimensional table
        fill every table field with 0 for amount of rows equal to available shares +1 and for amount of columns equal to available budget +1

        for current share in range(1 to available shares + 1):
                for current budget in range(1 to available budget + 1):
                        if total shares price[current share - 1] is lower or equal current budget:
                                fill table field[current share][current budget]
                                  with the maximum from
                                  (total profit[current share-1] + table field[current share-1][current budget - total shares price[current share- 1])
                                  or
                                  table field[current share-1][current budget]
                        else:
                                fill table field[current share][current budget] with table field[current share-1][current budget]

        while available budget is greater or equal 0 and amount of shares is greater or equal 0:
                if table field[amount of shares][available budget] is equal to
                  table field[amount of shares - 1][available budget - total shares price[amount of shares-1]] +
                  total profit[amount of shares-1]:
                        append available shares[amount of shares - 1] to share package
                        available budget -= total shares price[amount of shares - 1]
                        add price from available shares[amount of shares - 1] to total shares price
                        add profit from available shares[amount of shares - 1] to total profit
        return share package, total shares price, total profit
```

Dynamic programming method

	Price	Profit	0	1	2	3	4	5	6	7	8
-----------			0	0	0	0	0	0	0	0	0
Share 1	3	2	0	0	0	2	2	2	2	2	2
Share 2	4	3	0	0	0	2	3	3	3	5	5
Share 3	5	4	0	0	0	2	3	4	4	5	6
Share 4	6	1	0	0	0	2	3	4	4	5	6

$m[\,i\,,\,w\,] = \max(m[\,i\text{-}1\,,\,w\,],\, m[\,i\text{-}1\,,\,w - w[\,i\,]\,] + p[\,i\,])$
$m[\,4\,,\,7\,] = \max(m[\,3\,,\,7\,],\, m[\,3\,,\,7-6\,] + 1)$
$m[\,4\,,\,7\,] = \max(5,\,1)$
$m[\,4\,,\,7\,] = 5$

complexity is $O(m*N)$ where m is the number of every possible value (budget elements) and N is the number of items (shares)

Advantage:
- line code will be reduced due to recursive programming technique
- process is faster due to use of previously calculations

Disadvantage:
- takes a lot of memory, because every calculated subproblem will be stored if the result is going to be used or not
- functions are called recursively, so the stack memory keeps increasing

Chosen algorithm: Dynamic programming method

```python
def dynamic(available_shares, total_assets_available):
    # conversion to "cent" to match with price and profit
    total_assets_available_cent = total_assets_available * 100
    total_shares = len(available_shares)
    total_shares_price = []
    total_profit = []
    best_shares_package = []
    share_package_price = 0
    share_package_profit = 0

    # conversion to "cent" to avoid floats in table/matrix
    for share in available_shares:
        total_shares_price.append(int(share[1]*100))
        total_profit.append(((share[1] * 100) * share[2]) / 100)

    # building the table / matrix with all solutions of the sub-problems
    dp = [[0 for x in range(total_assets_available_cent + 1)] for y in range(total_shares + 1)]

    # first row/column is 0, starting therefore with 1
    for row in range(1, total_shares + 1):
        for column in range(1, total_assets_available_cent + 1):
            if total_shares_price[row-1] <= column:
                dp[row][column] = max(total_profit[row-1] + dp[row-1][column-total_shares_price[row-1]], dp[row-1][column])
            else:
                dp[row][column] = dp[row-1][column]

    # get information from picked shares until they are all processed
    while total_assets_available_cent >= 0 and total_shares >= 0:
        if dp[total_shares][total_assets_available_cent] == dp[total_shares-1][total_assets_available_cent - total_shares_price[total_shares-1]] + total_profit[total_shares-1]:
            best_shares_package.append(available_shares[total_shares-1])
            total_assets_available_cent -= total_shares_price[total_shares-1]
            share_package_price += price(available_shares[total_shares-1])
            share_package_profit += profit(available_shares[total_shares-1])
        total_shares -= 1
    return best_shares_package, share_package_price, share_package_profit
```

Comparison

m = 50000

	Brute force	Dynamic
N	2^N	m*N
5	32	250000
10	1024	500000
20	1048576	1000000
100	1.27E+30	5000000
500	3.27E+150	25000000
1000	1.07E+301	50000000

20 shares scenario:

```
Brute force method took: 2.1259818077087402 sec

Share-4: Price: 70.0€ - Profit: 14.0€
Share-5: Price: 60.0€ - Profit: 10.2€
Share-6: Price: 80.0€ - Profit: 20.0€
Share-8: Price: 26.0€ - Profit: 2.86€
Share-10: Price: 34.0€ - Profit: 9.18€
Share-11: Price: 42.0€ - Profit: 7.14€
Share-13: Price: 38.0€ - Profit: 8.74€
Share-18: Price: 10.0€ - Profit: 1.4€
Share-19: Price: 24.0€ - Profit: 5.04€
Share-20: Price: 114.0€ - Profit: 20.52€
We invest: 498.0€
Profit: 99.08€ after 2 years.
```

```
Greedy method (sorted by price) took: 0.0 sec

Share-20: Price: 114.0€ - Profit: 20.52€
Share-12: Price: 110.0€ - Profit: 9.9€
Share-6: Price: 80.0€ - Profit: 20.0€
Share-4: Price: 70.0€ - Profit: 14.0€
Share-5: Price: 60.0€ - Profit: 10.2€
Share-3: Price: 50.0€ - Profit: 7.5€
Share-14: Price: 14.0€ - Profit: 0.14€

We invest: 498.0€
Profit: 82.26€ after 2 years.
```

```
Greedy method (sorted by percent) took: 0.0 sec

Share-10: Price: 34.0€ - Profit: 9.18€
Share-6: Price: 80.0€ - Profit: 20.0€
Share-13: Price: 38.0€ - Profit: 8.74€
Share-19: Price: 24.0€ - Profit: 5.04€
Share-4: Price: 70.0€ - Profit: 14.0€
Share-20: Price: 114.0€ - Profit: 20.52€
Share-11: Price: 42.0€ - Profit: 7.14€
Share-5: Price: 60.0€ - Profit: 10.2€
Share-18: Price: 10.0€ - Profit: 1.4€
Share-17: Price: 4.0€ - Profit: 0.48€
Share-16: Price: 8.0€ - Profit: 0.64€
Share-14: Price: 14.0€ - Profit: 0.14€

We invest: 498.0€
Profit: 97.48€ after 2 years.
```

```
Greedy method (sorted by profit) took: 0.0 sec

Share-20: Price: 114.0€ - Profit: 20.52€
Share-6: Price: 80.0€ - Profit: 20.0€
Share-4: Price: 70.0€ - Profit: 14.0€
Share-5: Price: 60.0€ - Profit: 10.2€
Share-12: Price: 110.0€ - Profit: 9.9€
Share-10: Price: 34.0€ - Profit: 9.18€
Share-19: Price: 24.0€ - Profit: 5.04€
Share-16: Price: 8.0€ - Profit: 0.64€

We invest: 500.0€
Profit: 89.48€ after 2 years.
```

```
Dynamic method took: 0.27006077766418457 sec

Share-20: Price: 114.0€ - Profit: 20.52€
Share-19: Price: 24.0€ - Profit: 5.04€
Share-18: Price: 10.0€ - Profit: 1.4€
Share-13: Price: 38.0€ - Profit: 8.74€
Share-11: Price: 42.0€ - Profit: 7.14€
Share-10: Price: 34.0€ - Profit: 9.18€
Share-8: Price: 26.0€ - Profit: 2.86€
Share-6: Price: 80.0€ - Profit: 20.0€
Share-5: Price: 60.0€ - Profit: 10.2€
Share-4: Price: 70.0€ - Profit: 14.0€

We invest: 498.0€
Profit: 99.08€ after 2 years.
```

956 shares scenario:

```
Greedy method (sorted by percent) took: 0.0 sec

Share-XJMO: Price: 9.39€ - Profit: 3.75€
Share-KMTG: Price: 23.21€ - Profit: 9.28€
Share-MTLR: Price: 16.49€ - Profit: 6.59€
Share-GTQK: Price: 15.4€ - Profit: 6.15€
Share-LRBZ: Price: 32.9€ - Profit: 13.14€
Share-WPLI: Price: 34.64€ - Profit: 13.82€
Share-GIAJ: Price: 10.75€ - Profit: 4.29€
Share-GHIZ: Price: 28.0€ - Profit: 11.17€
Share-ZSDE: Price: 15.11€ - Profit: 6.03€
Share-IFCP: Price: 29.23€ - Profit: 11.66€
Share-FKJW: Price: 21.08€ - Profit: 8.39€
Share-NHWA: Price: 29.18€ - Profit: 11.6€
Share-LPDM: Price: 39.35€ - Profit: 15.63€
Share-QQTU: Price: 33.19€ - Profit: 13.14€
Share-USSR: Price: 25.62€ - Profit: 10.14€
Share-EMOV: Price: 8.89€ - Profit: 3.51€
Share-LGWG: Price: 31.41€ - Profit: 12.41€
Share-QLMK: Price: 17.38€ - Profit: 6.86€
Share-SKKC: Price: 24.87€ - Profit: 9.82€
Share-UEZB: Price: 24.87€ - Profit: 9.81€
Share-CBNY: Price: 1.22€ - Profit: 0.48€
Share-CGJM: Price: 17.21€ - Profit: 6.76€
Share-EVUW: Price: 4.44€ - Profit: 1.74€
Share-FHZN: Price: 6.1€ - Profit: 2.32€
Share-MLGM: Price: 0.01€ - Profit: 0.0€

We invest: 499.94€
Profit: 198.51€ after 2 years.
```

```
Greedy method (sorted by profit) took: 0.0010001659393310547 sec

Share-GRUT: Price: 498.76€ - Profit: 196.61€
Share-CBNY: Price: 1.22€ - Profit: 0.48€
Share-MLGM: Price: 0.01€ - Profit: 0.0€

We invest: 499.99€
Profit: 197.09€ after 2 years.
```

```
Greedy method (sorted by price) took: 0.0 sec

Share-GRUT: Price: 498.76€ - Profit: 196.61€
Share-CBNY: Price: 1.22€ - Profit: 0.48€
Share-MLGM: Price: 0.01€ - Profit: 0.0€

We invest: 499.99€
Profit: 197.09€ after 2 years.
```

```
Dynamic method took: 15.263623237609863 sec

Share-KMTG: Price: 23.21€ - Profit: 9.28€
Share-GHIZ: Price: 28.0€ - Profit: 11.17€
Share-NHWA: Price: 29.18€ - Profit: 11.6€
Share-UEZB: Price: 24.87€ - Profit: 9.81€
Share-LPDM: Price: 39.35€ - Profit: 15.63€
Share-MTLR: Price: 16.49€ - Profit: 6.59€
Share-USSR: Price: 25.62€ - Profit: 10.14€
Share-GTQK: Price: 15.4€ - Profit: 6.15€
Share-FKJW: Price: 21.08€ - Profit: 8.39€
Share-MLGM: Price: 0.01€ - Profit: 0.0€
Share-QLMK: Price: 17.38€ - Profit: 6.86€
Share-WPLI: Price: 34.64€ - Profit: 13.82€
Share-LGWG: Price: 31.41€ - Profit: 12.41€
Share-ZSDE: Price: 15.11€ - Profit: 6.03€
Share-SKKC: Price: 24.87€ - Profit: 9.82€
Share-QQTU: Price: 33.19€ - Profit: 13.14€
Share-GIAJ: Price: 10.75€ - Profit: 4.29€
Share-XJMO: Price: 9.39€ - Profit: 3.75€
Share-LRBZ: Price: 32.9€ - Profit: 13.14€
Share-KZBL: Price: 28.99€ - Profit: 11.35€
Share-EMOV: Price: 8.89€ - Profit: 3.51€
Share-IFCP: Price: 29.23€ - Profit: 11.66€

We invest: 499.96€
Profit: 198.55€ after 2 years.
```

```
Sienna bought:

Share-GRUT

Total cost: 498.76â,¬
Total return: 196.61â,¬
```

541 shares scenario:

```
Greedy method (sorted by price) took: 0.0 sec

Share-MBQU: Price: 51.46€ - Profit: 18.41€
Share-XJCP: Price: 50.88€ - Profit: 2.38€
Share-QEVK: Price: 49.77€ - Profit: 17.11€
Share-KLNI: Price: 49.68€ - Profit: 1.55€
Share-JWGF: Price: 48.69€ - Profit: 19.44€
Share-RGUQ: Price: 47.79€ - Profit: 8.83€
Share-DLCU: Price: 47.31€ - Profit: 6.08€
Share-QVUJ: Price: 47.27€ - Profit: 3.39€
Share-MALJ: Price: 46.37€ - Profit: 15.25€
Share-MDLX: Price: 46.12€ - Profit: 11.1€
Share-XYMR: Price: 14.49€ - Profit: 5.11€
Share-LKSD: Price: 0.12€ - Profit: 0.01€


We invest: 499.95€
Profit: 108.67€ after 2 years.


Greedy method (sorted by percent) took: 0.0 sec

Share-PATS: Price: 27.7€ - Profit: 11.07€
Share-ALIY: Price: 29.08€ - Profit: 11.61€
Share-JWGF: Price: 48.69€ - Profit: 19.44€
Share-PLLK: Price: 19.94€ - Profit: 7.96€
Share-NDKR: Price: 33.06€ - Profit: 13.19€
Share-FWBE: Price: 18.31€ - Profit: 7.29€
Share-LFXB: Price: 14.83€ - Profit: 5.9€
Share-ZOFA: Price: 25.32€ - Profit: 10.07€
Share-ANFX: Price: 38.55€ - Profit: 15.31€
Share-LXZU: Price: 4.24€ - Profit: 1.68€
Share-FAPS: Price: 32.57€ - Profit: 12.88€
Share-XQII: Price: 13.42€ - Profit: 5.3€
Share-ECAQ: Price: 31.66€ - Profit: 12.5€
Share-JGTW: Price: 35.29€ - Profit: 13.91€
Share-IXCI: Price: 26.32€ - Profit: 10.37€
Share-DWSK: Price: 29.49€ - Profit: 11.6€
Share-ROOM: Price: 15.06€ - Profit: 5.91€
Share-VCXT: Price: 29.19€ - Profit: 11.45€
Share-YFVZ: Price: 22.55€ - Profit: 8.82€
Share-OCKK: Price: 3.16€ - Profit: 1.15€
Share-JMLZ: Price: 1.27€ - Profit: 0.31€
Share-DYVD: Price: 0.28€ - Profit: 0.03€


We invest: 499.98€
Profit: 197.77€ after 2 years.
```

```
Greedy method (sorted by profit) took: 0.0 sec

Share-JWGF: Price: 48.69€ - Profit: 19.44€
Share-MBQU: Price: 51.46€ - Profit: 18.41€
Share-QEVK: Price: 49.77€ - Profit: 17.11€
Share-DLNE: Price: 44.06€ - Profit: 16.19€
Share-IJFT: Price: 40.91€ - Profit: 15.91€
Share-ANFX: Price: 38.55€ - Profit: 15.31€
Share-MALJ: Price: 46.37€ - Profit: 15.25€
Share-OPBR: Price: 39.0€ - Profit: 15.19€
Share-FWMV: Price: 41.68€ - Profit: 14.92€
Share-HATC: Price: 43.45€ - Profit: 14.83€
Share-XGNC: Price: 41.86€ - Profit: 14.71€
Share-XQII: Price: 13.42€ - Profit: 5.3€
Share-DYVD: Price: 0.28€ - Profit: 0.03€
Share-LKSD: Price: 0.12€ - Profit: 0.01€


We invest: 499.62€
Profit: 182.62€ after 2 years.


Dynamic method took: 8.350282669067383 sec

Share-ECAQ: Price: 31.66€ - Profit: 12.5€
Share-IXCI: Price: 26.32€ - Profit: 10.37€
Share-FWBE: Price: 18.31€ - Profit: 7.29€
Share-ZOFA: Price: 25.32€ - Profit: 10.07€
Share-PLLK: Price: 19.94€ - Profit: 7.96€
Share-LXZU: Price: 4.24€ - Profit: 1.68€
Share-YFVZ: Price: 22.55€ - Profit: 8.82€
Share-ANFX: Price: 38.55€ - Profit: 15.31€
Share-PATS: Price: 27.7€ - Profit: 11.07€
Share-SCWM: Price: 6.42€ - Profit: 2.45€
Share-NDKR: Price: 33.06€ - Profit: 13.19€
Share-ALIY: Price: 29.08€ - Profit: 11.61€
Share-JWGF: Price: 48.69€ - Profit: 19.44€
Share-JGTW: Price: 35.29€ - Profit: 13.91€
Share-FAPS: Price: 32.57€ - Profit: 12.88€
Share-VCAX: Price: 27.42€ - Profit: 10.69€
Share-LFXB: Price: 14.83€ - Profit: 5.9€
Share-DWSK: Price: 29.49€ - Profit: 11.6€
Share-XQII: Price: 13.42€ - Profit: 5.3€
Share-ROOM: Price: 15.06€ - Profit: 5.91€


We invest: 499.92€
Profit: 197.96€ after 2 years.
```

```
Sienna bought:
Share-ECAQ 3166
Share-IXCI 2632
Share-FWBE 1830
Share-ZOFA 2532
Share-PLLK 1994
Share-YFVZ 2255
Share-ANFX 3854
Share-PATS 2770
Share-NDKR 3306
Share-ALIY 2908
Share-JWGF 4869
Share-JGTW 3529
Share-FAPS 3257
Share-VCAX 2742
Share-LFXB 1483
Share-DWSK 2949
Share-XQII 1342
Share-ROOM 1506

Total cost: 489.24â,¬
Profit: 193.78â,¬
```