

Exercises 07: Optimization

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1 Exercise 3

The aim of this exercise is to benchmark Multiple - Choice Knapsack Problem with different items with their values and objects for multiple iterations.

The multiple-choice knapsack problem is a generalization of the ordinary knapsack problem, where the set of items is partitioned into classes. The binary choice of taking an item is replaced by the selection of exactly one item out of each class of items.

Mathematical formulation:

$$\text{maximize } \sum_{i=1}^k \sum_{j \in N_i} v_{ij} x_{ij} \text{ subject to } \sum_{i=1}^k \sum_{j \in N_i} w_{ij} x_{ij} \leq \text{limit}$$

$$\text{where } \sum_{j \in N_i} x_{ij} = 1, i = 1, \dots, k, x_{ij} \in \{0, 1\}, i = 1, \dots, k, j \in N_i$$

v - *Itemvalue*, w - *Itemweight*, k - *No.of items*, limit - *Weightlimit*,
 x_i - The number of instances of item i to include in the knapsack, $j \in N_i$

Steps:

1. Items generator: This function generates a given number of items with a random value between 1 to 20 and a weight between 1 to 10.
2. Recording execution time for the multiple iterations.
3. Calculating the mean of a recorded time set (i.e. Set of n).
4. Calculating variance of a recorded time set. (i.e. Set of n).
5. Visual representation of time vs iteration.

The following table represents the benchmarking results:

From the results, we can infer that the execution time depends on the no

| Sr. | Items | Iteration | Mean | std |
|------------|--------------|------------------|-------------|------------|
| 1 | 50 | 50 | 0.18 | 1.00 |
| 2 | 50 | 60 | 0.18 | 2.57 |
| 3 | 50 | 70 | 0.18 | 5.21 |
| 4 | 50 | 80 | 0.18 | 6.05 |
| 5 | 50 | 90 | 0.18 | 4.13 |
| 6 | 100 | 50 | 0.72 | 3.69 |
| 7 | 100 | 60 | 0.72 | 2.51 |
| 8 | 100 | 70 | 0.77 | 4.27 |
| 9 | 100 | 80 | 0.76 | 9.77 |
| 10 | 100 | 90 | 0.75 | 1.94 |
| 11 | 150 | 50 | 1.68 | 2.23 |
| 12 | 150 | 60 | 1.67 | 2.24 |
| 13 | 150 | 70 | 1.66 | 2.79 |
| 14 | 150 | 80 | 1.66 | 2.32 |
| 15 | 150 | 90 | 1.65 | 2.48 |
| 16 | 200 | 50 | 2.97 | 2.53 |
| 17 | 200 | 60 | 2.96 | 2.98 |
| 18 | 200 | 70 | 2.99 | 4.74 |
| 19 | 200 | 80 | 2.96 | 2.33 |
| 20 | 200 | 90 | 2.97 | 2.69 |
| 21 | 250 | 50 | 4.69 | 3.17 |
| 22 | 250 | 60 | 4.66 | 4.89 |
| 23 | 250 | 70 | 4.66 | 6.04 |
| 24 | 250 | 80 | 4.67 | 1.53 |
| 25 | 250 | 90 | 4.65 | 7.23 |

Table 1: Benchmarking results

of items. In the graph plot of Mean and Variance, the mean execution time increases as the number of items increases and the variance is almost the same all over the result.

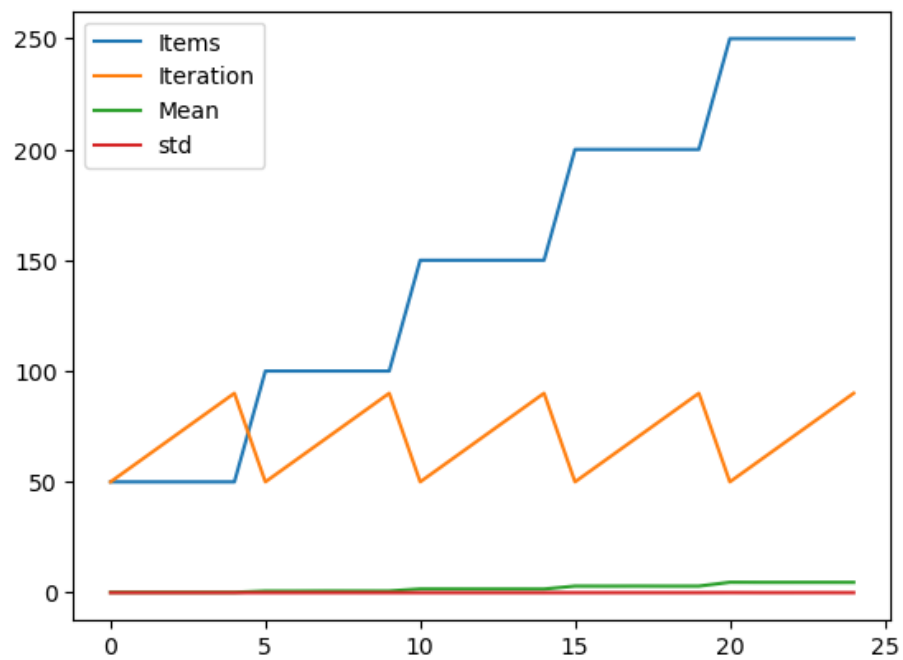


Figure 1: Items, Iteration, Mean and Variance Plot

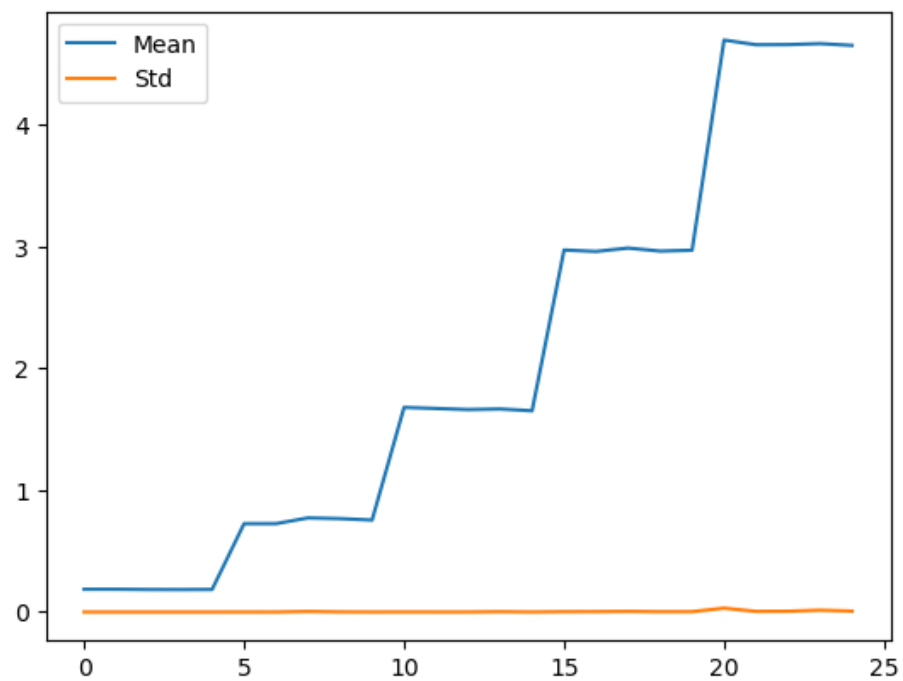


Figure 2: Mean³ and Variance Plot