**Benchmark of knapsack problem with Hill Climbing, Genetic Algorithm and Simulated Annealing**

To benchmark the speed and performance of the algorithms (Genetic Algorithm, Hill Climbing, and Simulated Annealing), we can compare their execution times and the quality of solutions they produce for different input sizes (10, 15, and 20 items).

Here's an overview of the comparison and observations:

1. Execution Time Comparison:

- For smaller input sizes (10 items), all three algorithms are expected to have relatively similar execution times, as the problem size is small.

- As the input size increases (15 and 20 items), the Genetic Algorithm is likely to have longer execution times compared to Hill Climbing and Simulated Annealing, due to its population-based approach and the need for multiple iterations to evolve the population.

2. Solution Quality or Total value Comparison:

- The Genetic Algorithm is expected to produce better solutions on average compared to Hill Climbing and Simulated Annealing. This is because the Genetic Algorithm explores a larger search space and has a better chance of finding optimal or near-optimal solutions.

- Hill Climbing is a local search algorithm that focuses on finding a single solution in the neighborhood of the current solution. It may get trapped in local optima and may not find the global optimum.

- Simulated Annealing is a probabilistic search algorithm that allows for occasional uphill moves to escape local optima. It is expected to find better solutions than Hill Climbing but might not perform as well as the Genetic Algorithm.

To present the findings, a table or graph can be used to compare the execution times and the quality of solutions produced by each algorithm for different input sizes. The table/graph can include columns/axes for the input size, execution time, and solution quality (total value achieved).

Example Table:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Input Size |  | Genetic Algorithm | Hill Climbing | Simulated Annealing |
| 10 | Time | 0.125 sec | 0.020 sec | 0.040 sec |
| Solution Quality | 950 | 800 | 900 |
| 15 | Time | 0.230 sec | 0.035 sec | 0.060 sec |
| Solution Quality | 1500 | 1200 | 1400 |
| 20 | Time | 0.350 sec | 0.045 sec | 0.080 sec |
| Solution Quality | 2000 | 1600 | 1800 |

Based on the observations, we can conclude that the Genetic Algorithm tends to provide better solutions, albeit at the cost of longer execution times. Hill Climbing and Simulated Annealing are faster but may not find optimal solutions consistently. The choice of algorithm depends on the trade-off between execution time and solution quality based on the problem requirements.