COS 314 Assignment 2

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**Technical Specification**

# Objective

The aim of this assignment is to implement the Genetic Algorithm and Ant Colony Optimization Algorithm and evaluate their effectiveness on the given datasets. The objective is to optimize these algorithms to obtain as many optimal solutions as possible, while minimizing the computation time, as well as critically analyze and compare the two meta-heuristics.

# Hardware Used

The assignment was completed on an Asus Vivobook Pro 17 laptop with the following specifications:

* CPU: Intel Core i7-8550U, with a clock speed of up to 4.0 GHz
* RAM: 16GB
* Operating System: Windows 11
* Development Environment: Visual Studio Code

# GA Configuration

The Genetic Algorithm was initially configured with the POPULATION\_SIZE to be 50 (Michalewicz, 2013) and the TOURNAMENT\_SIZE to be half of the current population. The MUTATION\_RATE was 0.01 and the CROSSOVER\_RATE was 0.9 (Goldberg, 1989). Lastly, the MAX\_GENERATIONS was set to 1000.

The configuration values were adjusted for better performance. Specifically, the POPULATION\_SIZE was set to be the same as the number of items in the knapsack. This made the population size dynamic based on the specific problem instance, which is important for achieving optimal results. Additionally, the TOURNAMENT\_SIZE was set to be a quarter of the current population to include a wider variety of chromosomes in the tournament. This was because setting it to half the population resulted in the tournament being too full of top fitness solutions. The MUTATION\_RATE was also increased to 0.05 to help escape local optimum. Finally, the MAX\_GENERATIONS was lowered to 500 to reduce computation time, as the optimal solution was often found before reaching 1000 generations.

## Experimental setup

Initially there was a high tournament selection size. This resulted in the algorithm hitting a local optimum and producing subpar results. This was emphasized with a low mutation rate. This was resolved when the mutation rate was increased and the tournament size was decreased, introducing a wider range of solutions into the population.

|  |  |  |
| --- | --- | --- |
| Parameter | Initial Value | Final value |
| POPULATION\_SIZE | 50 | No. of items |
| TOURNAMENT\_SIZE | Population / 2 | Population / 4 |
| MUTATION\_RATE | 0.01 | 0.05 |
| CROSSOVER\_RATE | 0.9 | 0.9 |
| MAX\_GENERATIONS | 1000 | 500 |

# ACO Configuration

The Ant Colony Optimization Algorithm was initially configured with the number of ants to be 50 (M. Dorigo, 1996). The pheromone deposit amount (Q) was equal to 1.0, the BETA value equal to 5.0, the RHO set to 0.5 and the ALPHA value equal to 1.0 (M. Dorigo, 1996). Lastly, the MAX\_ITERATIONS was set to 1000.

The configuration values were adjusted for better performance. Specifically, MAX\_ITERATIONS was lowered to 500 to reduce computation time, as the optimal solution was often found before reaching 1000 iterations. The heuristic information factor (BETA) was lowered to 2.0 to place more emphasis on the pheromone trails. Lastly, the number of ants was set equal to the number of items in the knapsack.

## Experimental Setup

Initially, the pheromone matrix was only updated where the current solution was better than the previous solution. This caused the algorithm to get stuck at local optimums as it was not encouraged to explore potentially worse solutions. This was solved by updating the pheromone matric even if it was a worse solution, but only updating the pheromone values a tenth of the amount as opposed to if the solution was better.

|  |  |  |
| --- | --- | --- |
| Parameter | Initial Value | Final Value |
| numAnts | 50 | No. of items |
| Q | 1.0 | 1.0 |
| BETA | 5.0 | 2.0 |
| ALPHA | 1.0 | 1.0 |
| RHO | 0.5 | 0.5 |
| MAX\_ITERATIONS | 1000 | 500 |

# Evaluation Metrics

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Problem Instance | Algorithm | Best Solution | Known Optimum | Runtime (seconds) |
| f1\_l-d\_kp\_10\_269 | ACO | 295 | 295 | 0.03 |
|  | GA | 295 | 0.13 |
| f2\_l-d\_kp\_20\_878 | ACO | 1024 | 1024 | 0.13 |
|  | GA | 1024 | 0.03 |
| f3\_l-d\_kp\_4\_20 | ACO | 35 | 35 | 0.0 |
|  | GA | 35 | 0.0 |
| f4\_l-d\_kp\_4\_11 | ACO | 23 | 23 | 0.0 |
|  | GA | 23 | 0.0 |
| f5\_l-d\_kp\_15\_375 | ACO | 481.0694 | 481.0694 | 0.03 |
|  | GA | 481.0694 | 0.0 |
| f6\_l-d\_kp\_10\_60 | ACO | 52 | 52 | 0.0 |
|  | GA | 52 | 0.0 |
| f7\_l-d\_kp\_7\_50 | ACO | 107 | 107 | 0.0 |
|  | GA | 107 | 0.0 |
| f8\_l-d\_kp\_23\_10000 | ACO | 9757 | 9767 | 0.17 |
|  | GA | 9767 | 0.03 |
| f9\_l-d\_kp\_5\_80 | ACO | 130 | 130 | 0.0 |
|  | GA | 130 | 0.0 |
| f10\_l-d\_kp\_20\_879 | ACO | 1025 | 1025 | 0.07 |
|  | GA | 1025 | 0.03 |
|  | | | **Total time:** | **ACO**: 0.43 |
| **GA**: 0.22 |

# Results

# References

1. Goldberg, D. E., 1989. *Genetic algorithms in search, optimization, and machine learning..* 75 Arlington Street, Suite 300 Boston, MA United States: Addison-Wesley Longman Publishing Co., Inc..
2. M. Dorigo, V. M. a. A. C., 1996. Ant system: optimization by a colony of cooperating agents. *IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), vol. 26, no. 1,* pp. 29-41.
3. Michalewicz, Z. a. D. B. F., 2013. *How to solve it: modern heuristics..* Berlin: Springer, Berlin, Heidelberg.