**Assessment Task 1 - Evaluation Report (AI for Search and Optimisation)**

**Abstract**

This is the evaluation report for solving the bin-packing problem using a single-member algorithm. The task of the given assignment is to use one of the variants of hill climbing, simulated annealing, or tabu search to solve the one-dimensional bin-packing problem. This documentation aims to achieve the minimum number of bins using two approaches: Best Fit + Simulated Annealing and First Fit Decreasing + Simulated Annealing.

1. **Introduction to Bin-Packing problem and Simulated Annealing**

The bin-packing problem is a NP-hard optimisation problem, where the goal is to distribute the items in a way that minimises the number of bins used, given several items with different weights and a fixed bin capacity. There are several heuristic methods used to solve the bin-packing problem. For this assignment Best Fit, First Fit Decreasing, and Simulated Annealing have been utilized to solve the problem.

The simulated annealing does not guarantee an optimal solution but can reach good solution within a reasonable time. The simulated annealing can escape the local optima by accepting worse solutions using Metropolis criteria and Boltzmann distributions  [(SONUC, et al., 2017)](#ref4).

1. **Methodology**

This report evaluates and compare two solutions generated using: 1) the best-fit as the initial solution, 2) the first-fit decreasing as the initial solution. Best-fit (BF) bin packing involves searching for the bin with the maximum available space to fit the current item. If the item doesn’t fit, it’ll go to the next possible bin. In First-fit decreasing (FFD), the items are initially sorted in the decreasing order and then placed in the first bin where they fit.

New Candidates – New candidates are generated through one to zero and zero to one swapping (one random item from a random bin is selected and placed in another random bin) and one to one swapping (two random items are selected from two random bins and swapped with each other).

Objective function – The goal in this assessment is to minimize the bins while also maximizing the empty space. The objective function determines the energy level of each solution which is used to decide whether to accept the new candidate by the acceptance criterion. The mathematical formula for this is extracted from the paper published by Sonuc, Emrullah and others  [(SONUC, et al., 2017)](#ref4).

m = no. of bins, ki = number of items in bin, wj = weight of the item in bin ki

1. **Evaluation of performance**

Cooling rate = 0.95, maximum iterations = 100000, initial temperature = 1000, stopping temperature = 0.01 are used as parameter configurations. The following table shows objective function value and the minimum level of bins achieved.

|  |  |  |  |
| --- | --- | --- | --- |
| Function | Max. Objective (rounded) | Initial Minimum Bins | Final Minimum Bins |
| Best Fit + SA | 783,475 | 89 (BF) | 89 (BF + SA) |
| First Fit Decreasing + SA | 783,475 | 94 (FFD) | 94 (FFD + SA) |

The figure shown below depicts the immediate increase of the empty space available with each iteration on Best Fit and Simulated Annealing.

A graph with blue lines

Description automatically generated

Figure 1: BF + SA maximum empty space increase

The figure shown below depicts the slower but a gradual increase of the empty space available with each iteration on FFD and Simulated Annealing.

A graph with a line

Description automatically generated

Figure 2: FFD + SA maximum empty space increase

1. **Conclusion**

In conclusion, there’re several heuristic methods we can apply to solve the bin-packing problem. In this report, the BF+SA were able to generate lower number of bins with maximum number of empty space than the FFD+SA. However, the initial number of bins remained unchanged throughout the iterations of both applications and did not see any improvement.

# **References**

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