Assignment 1 Part 2 BPP

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Representation of Solutions

Each potential solution, referred to as a chromosome, is represented as a list of integers where each integer corresponds to a bin index. The chromosome is a one-dimensional array with each gene representing the bin number that an item is placed into. The length of the chromosome is equal to the total number of items across all item weights, and the value at each position i in the chromosome determines the bin into which item i is assigned.

The integer list representation is a natural fit for the bin packing problem, as it mirrors the process of assigning items to specific bins. The representation aligns with the goal of minimising the amount of bins used as the fitness function can directly count the unique bins present in the chromosome which gives the total number of bins used and does not give us a decimal as that wouldn't make sense in this context.

Description of Functions

Fitness

- Each chromosome represents a bin packing configuration, where each gene indicates the bin index an item is placed in. The fitness function sums the weights of items in each bin and counts the number of valid bins (bins where the weight does not go over the capacity limit).
- We chose to do the fitness function this way to make it as suitable as possible for the BPP. Only valid bins are counted in order to not go over the bin capacity which makes the model use as few bins as possible whilst simultaneously not exceeding the limit.

Selection

- This operator randomly selects individuals for reproduction but gives a higher probability to individuals with higher fitness, therefore they have a higher chance of selection.
- This approach ensures diversity but also ensures fitter individuals are more likely to be chosen which leads to better solutions over time.

Crossover

- A random crossover point is selected, and the parts of the parent chromosomes before this point are swapped to create two new offspring. (One-Point Crossover)
- This is a similar approach to the one used in part 1. It has the potential to create better solutions by inheriting features from 2 good solutions(parents).

Mutation

- Each gene in the chromosome has a chance (defined by the mutation rate) of being changed. In the context of the BPP, this means changing the bin that an item is in.
- Mutation allows for genetic diversity and allows the algorithm to search for a wider range of solutions and helps avoid early convergence.

Problem Landscape

- A genetic algorithm for the BPP needs to find a balance between exploring the solution space (finding new solutions) and exploiting known good solutions. Too much exploration might lead to slow convergence, while too much exploitation might cause the algorithm to get stuck in local optima. This becomes more apparent the more complex and the more data there is to the problem.
- When we were experimenting with the mutation rate value, we noticed that even if we change the value significantly it does not have a massive impact on the output which potentially indicates that the current population has sufficient diversity.

References

Problem Landscape - What is a Genetic Algorithm (youtube.com)

BPP Algorithm - Bin Packing Problem (Minimize number of used Bins) - GeeksforGeeks