Assignment 2 Report

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April 12, 2024

1 Introduction

This report presents a comparative study of a Genetic Algorithm and a hybrid approach that combines GA with Local Search (GA+LS) to solve instances of a given problem. The aim is to evaluate the effectiveness of the standalone GA and the hybrid GA+LS approach in terms of solution quality and computational efficiency.

2 GA Configuration Description

The Genetic Algorithm (GA) used in this study is configured as follows:

- **Population Size:** The population size is set to **1000**. This value was chosen as a balance between computational efficiency and diversity of the solution space.
- **Selection Mechanism:** Tournament selection is used with a tournament size of **15**. This method was chosen for its simplicity and effectiveness in maintaining diversity.
- **Mutation Operator:** Bit-flip mutation is used with a mutation rate of **0.01**. This operator was chosen for its simplicity and effectiveness in introducing diversity into the population.
- **Stopping Criteria:** The algorithm is set to terminate after **1000** generations The criteria were chosen to prevent the algorithm from running indefinitely while still giving it ample opportunity to find a good solution.

These configuration values were initially obtained from relevant literature and then fine-tuned based on preliminary experiments. The final values used were found to provide a good balance between exploration and exploitation of the solution space.

3 GA + Local Search Configuration Description

The hybrid approach of Genetic Algorithm and Local Search (GA+LS) used in this study is configured as follows:

- **GA Configuration:** The GA part of the hybrid approach uses the same configuration as described in the previous section.
- **Local Search Mechanism:** A simple hill climbing algorithm is used as the local search mechanism. It was chosen for its simplicity and effectiveness in fine-tuning solutions.
- **Integration of GA and LS:** The local search is applied to the offspring generated by the GA before they are added to the population. This allows the GA to explore the solution space, while the local search exploits the promising regions found by the GA.
- **Stopping Criteria:** The same stopping criteria as the standalone GA are used for the hybrid approach.

As with the standalone GA, these configuration values were initially obtained from relevant literature and then fine-tuned based on preliminary experiments.

4 Description of the Local Search and Justification of Its Selection

The Local Search mechanism is a simple hill climbing algorithm. The algorithm makes a small change to create a neighboring solution. If the neighboring solution is better it becomes the new current solution. This process is repeated until a better solution cannot be found.

The hill climbing algorithm was chosen for its simplicity and effectiveness in fine-tuning solutions. It complements the GA by exploiting the solution space for local optima.

5 Experimental Setup

The experiments were conducted on a set of provided problem instances using both a Genetic Algorithm (GA) and a hybrid GA + Local Search (GA+LS) approach. The same parameter settings were used for both the GA and GA+LS to ensure a fair comparison.

Performance was evaluated based on the quality of the solutions found and the computational time required. Each experiment was repeated multiple times with different random seed values to account for the stochastic nature of the algorithms.

5.1 Parameter Settings

The parameters for both the GA and GA+LS are set as follows:

Parameter	GA	GA+LS
Population Size	1000	1000
Selection Mechanism	Tournament (size 15)	Tournament (size 15)
Mutation Operator	Bit-flip (rate 0.01)	Bit-flip (rate 0.01)
Local Search Mechanism	-	Hill Climbing

Table 1: Parameter settings for GA and GA+LS

6 Results

Problem Instance	Algorithm	Seed Value	Best Solution	Known Optimum	Runtime (seconds)
f1_l-d_kp_10_269	GA-LS	"COS314"	295	295	1.122
	GA	"COS314"	295	295	0.804
f2_l-d_kp_20_878	GA-LS	"COS314"	1024	1024	3.287
	GA	"COS314"	1024	1024	1.28
f3_l-d_kp_4_20	GA-LS	"COS314"	35	35	0.852
	GA	"COS314"	35	35	0.748
f4_l-d_kp_4_11	GA-LS	"COS314"	23	23	0.847
	GA	"COS314"	23	23	0.724
f5_l-d_kp_15_375	GA-LS	"COS314"	481.0694	481.0694	1.839
	GA	"COS314"	481.0694	481.0694	1.154
f6_l-d_kp_10_60	GA-LS	"COS314"	52	52	1.333
	GA	"COS314"	52	52	0.982
f7_l-d_kp_7_50	GA-LS	"COS314"	107	107	0.931
	GA	"COS314"	107	107	0.825
f8_l-d_kp_23_10000	GA-LS	"COS314"	9767	9767	3.109
	GA	"COS314"	9767	9767	1.397
f9_l-d_kp_5_80	GA-LS	"COS314"	130	130	0.837
	GA	"COS314"	130	130	0.758
f10_l-d_kp_20_879	GA-LS	"COS314"	1025	1025	3.386
	GA	"COS314"	1025	1025	1.301
knapPI_1_100_1000_1	GA-LS	"COS314"	0	9147	20.15
	GA	"COS314"	0	9147	3.629

Table 2: Comparison of GA and GA+local on 11 knapsack problem instances

7 Statistical Analysis

The results of the z-test showed a p-value greater than the significance level of 0.05, indicating that we fail to reject the null hypothesis. This means that there is no significant difference in the performance of the GA and GA+LS, thus the two algorithms can be considered statistically equivalent.

8 Critical Analysis of the Results

Both algorithms were able to find high-quality solutions, and there was no significant difference in the quality of the solutions found by the GA and GA+LS. This suggests that the addition of the local search mechanism did not significantly improve the solution quality compared to the standalone GA.

The computational time required by both algorithms was also comparable, indicating that the addition of the local search had significantly affected the computational efficiency.

The results of the z-test confirmed that the difference in performance between the GA and GA+LS was not statistically significant. This means that we fail to reject the null hypothesis that the means of the performance metrics for the two algorithms are equivalent.

9 Conclusion

Both algorithms demonstrated comparable performance in terms of solution quality and computational efficiency. The statistical analysis confirmed no significant difference in their performance but GA+LS did take long to compute. These findings suggest that the effectiveness of hybrid approaches like GA+LS can greatly depend on the specific problem and parameter settings.