Exercise 3: Genetic Algorithm (Uniform Crossover)

Setup

- Suite: PBO (F1, F2, F3, F18, F23, F24, F25), dimension 100, instance 1.
- Budget: 100k evaluations, 10 runs per function.
- **Ex3 - GA:** uniform crossover (pc=1.0), bit-flip mutation pm≈1/n, μ=20 parents, λ=20 offspring, tournament k=3, (μ+λ) survivor selection with elitism.
- Baselines for comparison: Random Search, RLS-EA, (1+1)-EA (same budget).
- Logging via IOHexperimenter; plots and table exported from IOHanalyzer.

Why this GA?

(1) Uniform XO mixes schemata gene-wise for exploration.

(2) pm≈1/n; gives ~1 bit flip per offspring; standard for bit-strings.

(3) Tournament selection adds moderate pressure without losing diversity.

(4) (μ+λ)+elitism; ensures non-decreasing best-so-far.

Results at final budget (100k evals)

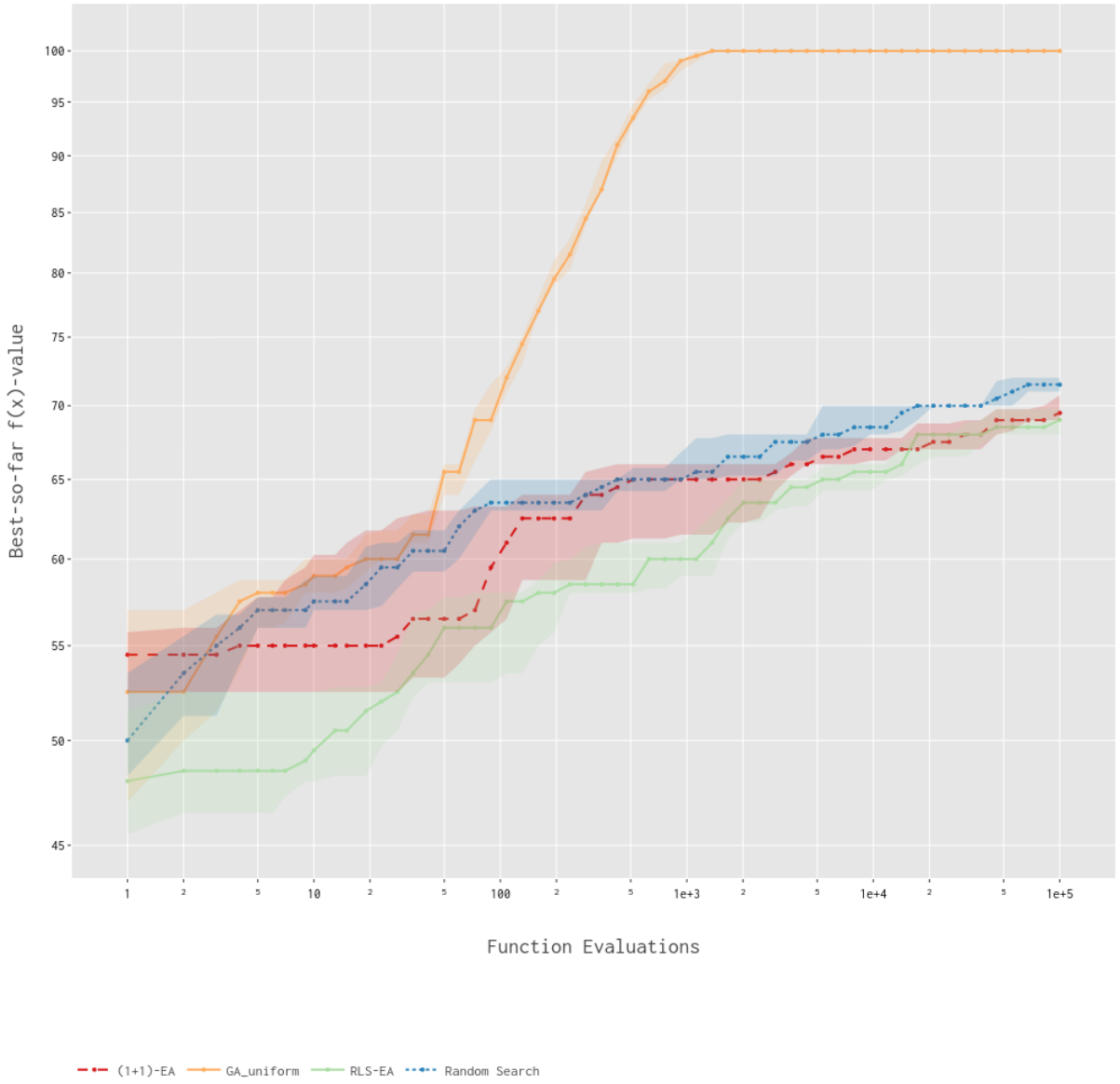
Medians from ex3_fixedbudget_100k (IOH shows 100,001)(Higher is better: max)

Function ID	Function	GA (median)	Best baseline (median)	Best baseline (name)	Δ (GA − best)
1	OneMax	100	71.5	Random Search	28.5
2	LeadingOnes	100	17.5	Random Search	82.5
3	Linear	5050	3755.5	Random Search	1294.5
18	LABS	3.943698	2.36621	Random Search	1.577489
23	NQueens	9	-563	Random Search	572
24	ConcatenatedTrap	16.8	11.8	Random Search	5
25	NKLandscapes	-0.293935	-0.4042	Random Search	0.110266

Per-function takeaways

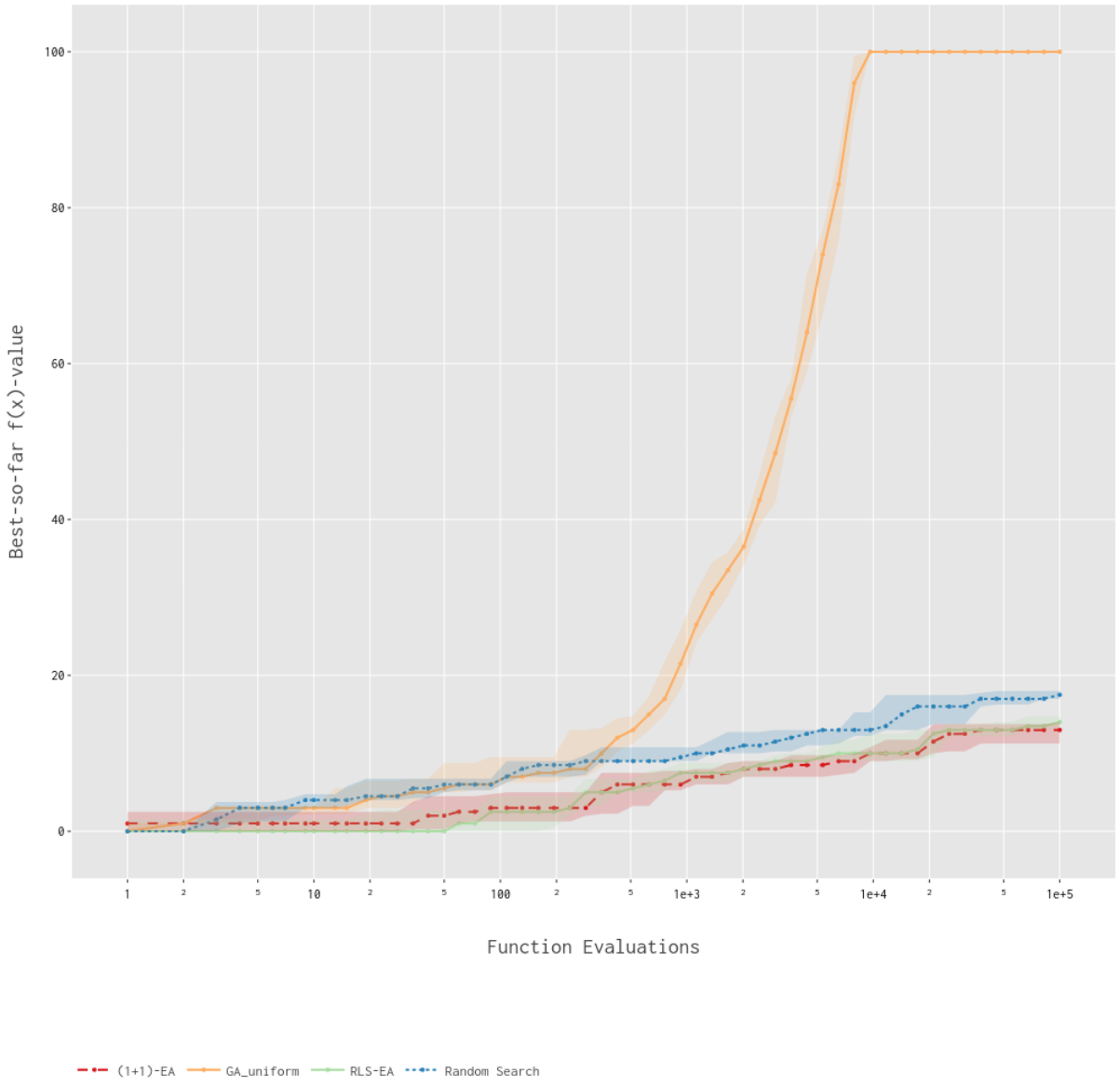
From the plots

F1*(OneMax)*



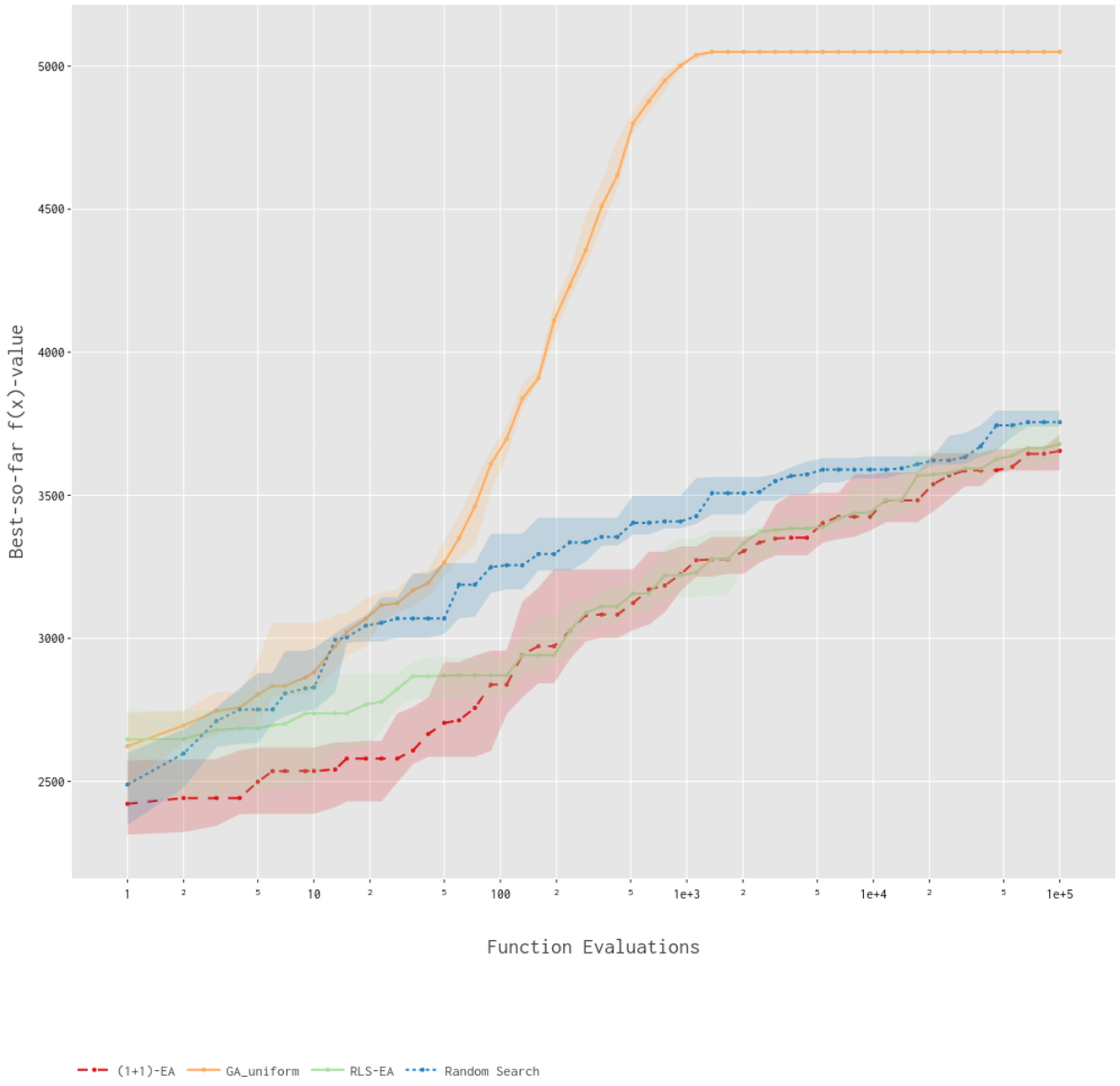
- **F1:** GA reaches the optimum (100/100) on all runs; baselines plateau ≈70. Selection + pm≈1/n quickly corrects bits; elitism keeps gains.

F2*(LeadingOnes)*



- **F2:** GA also reaches optimum; despite XO potentially breaking prefixes, elitism and moderate pm prevent regressions and preserve long prefixes.

F3*(Linear)*



- **F3:** GA attains the weighted-sum optimum (5050). Population + tournament accelerate alignment with weights.

F18*(LABS),* **F23***(NQueens)*, **F24***(ConcatenatedTrap)*, **F25***(NKLandscapes)*

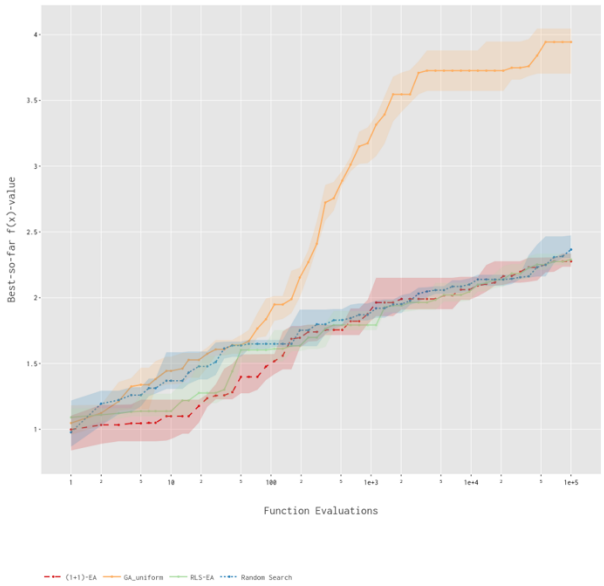


Figure 1(F18)

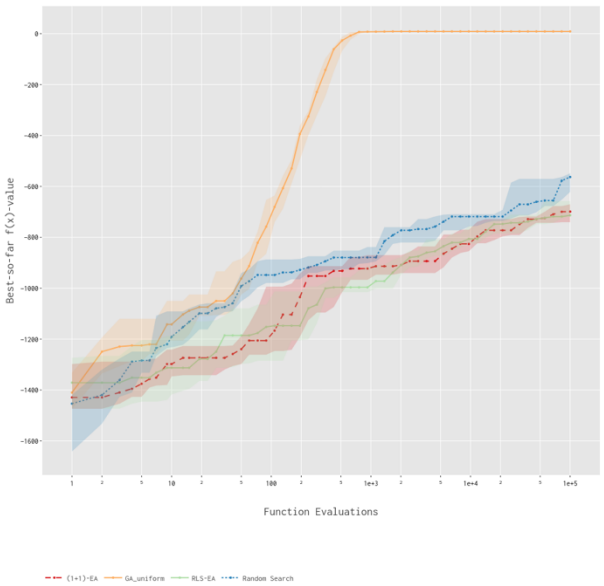


Figure 2(F23)

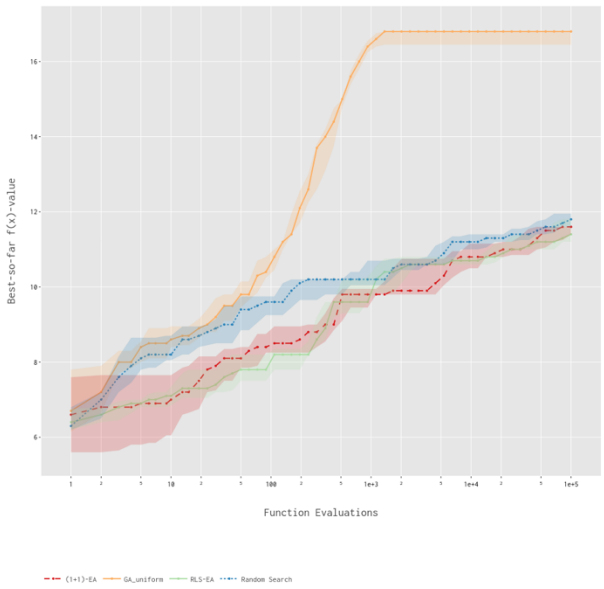


Figure 3(F24)

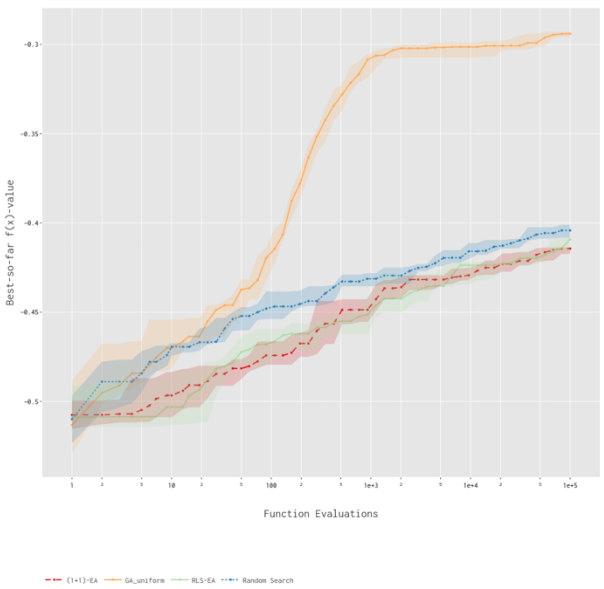


Figure 4(F25)

- **F18/F23/F24/F25:** GA dominates throughout the budget. A population with uniform XO maintains diversity and escapes local traps; (μ+λ) ensures steady best-so-far improvement.

Observed stability

- On F1/F2/F3 the interquartile band collapses near the max (low variance); on rugged problems the IQR is wider early, then tightens as selection amplifies improvements.

Tuning

- No additional tuning was performed as the default GA (μ=λ=20, k=3, pm≈1/n, pc=1.0, (μ+λ) elitism) already dominated the baselines at the same budget.

Conclusion

Across all seven PBO functions at n=100 and equal budgets, the GA with uniform crossover (pc=1.0), pm≈1/n, μ=λ=20, tournament k=3, and (μ+λ) elitism dominates the baselines. It reaches the known optima on F1/F2/F3 with negligible variance and shows clear gains on rugged/plateaued landscapes (F18/F23/F24/F25). No tuning was required.