Program-based Automatic Repair Prototype

CS 6720 – Fall 2025 Project Report

Name: Kevin Bell
Repository: https://github.com/bell-kevin/PAR-tool

Project Overview. This project delivers a Java re-implementation of the PAR (Program-based Automatic Repair) workflow for Python programs. The tool copies a subject project into an isolated workspace, applies mutation and pattern-based operators to a designated Python file, and evaluates each candidate with a user-supplied regression test command. The prototype supports eight mutation operators, a lightweight fault/fix knowledge base, and crossover to combine promising candidates.

Design Highlights.

- A command-line runner (`com.par.tool.ParTool`) coordinates project cloning, mutation search, scoring, and artifact production under `_apr_results/`.

- Mutation operators include statement deletion/duplication/swapping, arithmetic and comparison replacements, conditional negation, and small-integer tweaking. A pattern-based operator injects reusable repair templates.

- The scoring system parses `pytest` output to prioritize candidates that reduce failures and stop early when a full repair is found.

Experimental Setup. Three self-contained Python fixtures were crafted to evaluate the repair workflow. Each fixture provides a buggy module and `pytest` suite. The prototype was executed with a search budget of 40 candidates, a 30-second per-test timeout, Python 3.11, and `pytest` 7.4.

Subject	Failure Mode	Baseline (fail/error/pass)	Outcome
`null_guard`	Missing None guard on method call	1 / 0 / 1	Fixed via `NullCheckGuard`.
`none_equality`	Equality check triggers custom `__eq__`	1 / 0 / 2	Fixed via identity comparison.
`bounds_check`	Out-of-range list access	2 / 0 / 1	Fixed via bounds guard.

Across all three benchmarks the tool synthesized a repair that restored the test suite, demonstrating end-to-end functionality and validating the mutation operators and pattern-matching components. Detailed artifacts (summary JSON, diffs, and repaired source) are included in `experiments/`.

Challenges. Engineering the pattern-based operator required designing compact abstractions for recurring bug/fix pairs without overfitting to a single project. Balancing search depth and runtime was addressed by tuning operator probabilities and adding cheap heuristics to score candidates early.

Future Work. Next steps include integrating richer statistical fault localization, expanding the fix database with more Python-specific templates, and evaluating the tool on open-source defect datasets such as QuixBugs or BugsInPy.

Terminal Output. The following log captures the environment setup and experiment execution on Windows PowerShell.

```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows

PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> java --version
openjdk 21.0.8 2025-07-15 LTS
OpenJDK Runtime Environment Temurin-21.0.8+9 (build 21.0.8+9-LTS)
OpenJDK 64-Bit Server VM Temurin-21.0.8+9 (build 21.0.8+9-LTS, mixed mode, sharing)
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> python --version
Python 3.13.3
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> scoop install maven
Updating Scoop...
Updating Buckets...
 * 2801ef068859 sqlite@3.51.1: Fix hash (Closes #7422)            main       17
 ↪   minutes ago
 * 09c2db91a447 sqldef: Update to version 3.7.2                   main       37
 ↪   minutes ago
 * 00100e74f25a flyctl: Update to version 0.3.229                 main       37
 ↪   minutes ago
 * 7690eec35a09 dolt: Update to version 1.78.6                    main       37
 ↪   minutes ago
 * 7ec9346fdff4 cuda: Update to version 13.1.0                    main       37
 ↪   minutes ago
 * ca1446d81371 codex: Update to version 0.65.0                   main       37
 ↪   minutes ago
 * c90272fd9031 aws: Update to version 2.32.10                    main       37
 ↪   minutes ago
 * e2c17d08b6e4 jdupes@1.31.1: Fix download URL & hash (Closes #7419)  main   3
 ↪   hours ago
 * a67b196ffa5b wakatime-cli: Update to version 1.132.1           main       5
 ↪   hours ago
 * 3cedb86942d2 ruff: Update to version 0.14.8                    main       5
 ↪   hours ago
 * 855816717e1f poppler: Update to version 25.12.0-0              main       5
 ↪   hours ago
 * fd58ab7597a5 pocketbase: Update to version 0.34.2              main       5
 ↪   hours ago
 * 3bb1a624cfa0 okteto: Update to version 3.14.0                  main       5
 ↪   hours ago
 * 7efb4df40640 jsonschema: Update to version 12.10.0             main       5
 ↪   hours ago
 * d951c3a5223f golangci-lint: Update to version 2.7.1            main       5
 ↪   hours ago
 * 1ef30b1e7f3d exiftool: Update to version 13.43                 main       5
 ↪   hours ago
 * 57d9965f89f1 broot@1.54.0: Fix hash (Closes #7421)             main       6
 ↪   hours ago
 * 2b9ffc1e6990 mise: Update to version 2025.12.0                 main       9
 ↪   hours ago
 * fd3a0c50ba62 kimi-cli: Update to version 0.61                  main       9
 ↪   hours ago
```

```
* ed29d89536b4 rustic: Update to version 0.10.2 (#7399)              main         10
↪   hours ago
* 2d05c85dc90c supabase: Update to version 2.65.5                    main         13
↪   hours ago
* 0aa355e70da1 jj: Update to version 0.36.0                          main         13
↪   hours ago
* e7fb6c0d6509 pkl-cli: Update to version 0.30.1                     main         20
↪   hours ago
* ac0a5e0c23c1 nuget: Update to version 7.0.1                        main         20
↪   hours ago
* 4784aa1ad59f istioctl: Update to version 1.28.1                    main         20
↪   hours ago
* 91ab8a31b435 firebase: Update to version 14.27.0                   main         20
↪   hours ago
* b44aa9f2fcfd cockroachdb: Update to version 25.4.1                 main         20
↪   hours ago
* 3212da8f39f2 chezmoi: Update to version 2.68.0                     main         20
↪   hours ago
* 9439b396040e cc65: Update to version 19909321171                   main         20
↪   hours ago
* d66b981742db balena-cli: Update to version 23.2.4                  main         20
↪   hours ago
* ca9ac095ffee aws-sam-cli: Update to version 1.150.1               main         20
↪   hours ago
* a23ebc2b3df2 zvm: Update to version 0.8.11                         main         25
↪   hours ago
* fff05e247c6f typst: Update to version 0.14.1                       main         25
↪   hours ago
* 93c1109df2e2 sqldef: Update to version 3.7.1                       main         25
↪   hours ago
* 3441d06c1f44 pulumi: Update to version 3.210.0                     main         25
↪   hours ago
* 489473e49346 jsonschema: Update to version 12.9.3                  main         25
↪   hours ago
* c41686f88f89 harper: Update to version 1.1.0                       main         25
↪   hours ago
* 7facbdf872b1 groovy: Update to version 5.0.3                       main         25
↪   hours ago
* 77b9a0e12c12 golangci-lint: Update to version 2.7.0               main         25
↪   hours ago
* 399777424e02 flyctl: Update to version 0.3.228                     main         25
↪   hours ago
* e413cd46069e broot: Update to version 1.54.0                       main         25
↪   hours ago
* 1293597bb404 aws: Update to version 2.32.9                         main         25
↪   hours ago
* f289ab5ce8ff wakatime-cli: Update to version 1.132.0              main         29
↪   hours ago
* b9d9272a7f9e terraform-provider-ibm: Update to version 1.86.0     main         29
↪   hours ago
* cd5ea11ea6f1 sonar-scanner: Update to version 8.0.0.6341          main         29
↪   hours ago
* d6f2773f0218 quarkus-cli: Update to version 3.30.2                 main         29
↪   hours ago
```

```
* 5480fc77614d metabase: Update to version 0.57.5                main      29
↳   hours ago
* a208cc456a09 meilisearch: Update to version 1.28.2             main      29
↳   hours ago
* ad92b485c524 lefthook: Update to version 2.0.7                 main      29
↳   hours ago
* 40cb771c0c1d jsonschema: Update to version 12.9.1              main      29
↳   hours ago
* 468988ab6641 jdtls: Update to version 1.55.0-202512031605      main      29
↳   hours ago
* ccef3c8efe60 git-machete: Update to version 3.38.0             main      29
↳   hours ago
* f447db35efbc cmctl: Update to version 2.4.0                    main      29
↳   hours ago
* 717cc19b8e46 trivy: Update to version 0.68.1                   main      33
↳   hours ago
* 41506f798030 trid: Update to version 2.46-25.12.03             main      33
↳   hours ago
* e256e42e9684 terraform: Update to version 1.14.1               main      33
↳   hours ago
* 82cd42e47f12 sqldef: Update to version 3.7.0                   main      33
↳   hours ago
* 06d5a8832fec solidity: Update to version 0.8.31                main      33
↳   hours ago
* a230d83a7599 pixi: Update to version 0.60.0                    main      33
↳   hours ago
* d75abe76360d llvm: Update to version 21.1.7                    main      33
↳   hours ago
* 2d65dba9e5fa kyverno-cli: Update to version 1.16.1             main      33
↳   hours ago
* 7175f670af12 lefthook: Update to version 2.0.6                 main      2
↳   days ago
* 6a641be33db9 crc: Update to version 2.57.0                     main      2
↳   days ago
* 105b3f0273dd aliyun: Update to version 3.2.0                   main      2
↳   days ago
* 0135ebc921d7 uv: Update to version 0.9.15                      main      2
↳   days ago
* 83974425dadc supabase: Update to version 2.65.2                main      2
↳   days ago
* 369acfe44fc1 openshift-okd-client: Update to version 4.21.0-okd-sco.. main   2
↳   days ago
* bf2ed8951779 luau: Update to version 0.702                     main      2
↳   days ago
* 11d7985dbf32 aws-sam-cli: Update to version 1.150.0            main      2
↳   days ago
Scoop was updated successfully!
WARN  'maven' (3.9.11) is already installed.
Use 'scoop update maven' to install a new version.
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> choco -v
2.4.3
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> $env:PATH +=
↳   ";$env:USERPROFILE\scoop\apps\maven\current\bin"
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> mvn -v
```

```
Apache Maven 3.9.11 (3e54c93a704957b63ee3494413a2b544fd3d825b)
Maven home: C:\Users\Kevin Bell\scoop\apps\maven\current
Java version: 21.0.8, vendor: Eclipse Adoptium, runtime: C:\Program Files\Eclipse
↪  Adoptium\jdk-21.0.8.9-hotspot
Default locale: en_US, platform encoding: UTF-8
OS name: "windows 11", version: "10.0", arch: "amd64", family: "windows"
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> mvn -q clean compile
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> java -cp target/classes
↪  com.par.tool.ParTool `
>>    --project "$PWD/experiments/null_guard/project" `
>>    --target  "$PWD/experiments/null_guard/project/strings.py" `
>>    --tests   "pytest -q" `
>>    --budget  200 `
>>    --timeout 120
BASELINE EXIT: 1
BASELINE SUMMARY: failed=1, errors=0, passed=1
Detected fault patterns: [NullDereference]
Detected 32 logical processors; using 32 worker threads.
[28/200] Crossover of [StatementDeleteOperator line=4] + [StatementSwapOperator
↪  lines=4/5] -> exit=2 score=1 summary=failed=0, errors=1
[29/200] StatementSwapOperator lines=9/10 -> exit=2 score=1 summary=failed=0, errors=1
[30/200] Crossover of [StatementDuplicateOperator line=5] + [StatementSwapOperator
↪  lines=7/8] -> exit=2 score=1 summary=failed=0, errors=1
[27/200] Crossover of [StatementDeleteOperator line=5] + [StatementDeleteOperator line=8]
↪  -> exit=2 score=1 summary=failed=0, errors=1
[1/200] ArithmeticOperator line=4 replace=-->+ -> exit=2 score=1 summary=failed=0,
↪  errors=1
[18/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDeleteOperator
↪  line=9] -> exit=2 score=1 summary=failed=0, errors=1
[23/200] StatementDuplicateOperator line=5 -> exit=2 score=1 summary=failed=0, errors=1
[21/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDeleteOperator
↪  line=10] -> exit=2 score=1 summary=failed=0, errors=1
[19/200] Crossover of [StatementDuplicateOperator line=4] + [StatementSwapOperator
↪  lines=9/10] -> exit=2 score=1 summary=failed=0, errors=1
[22/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDuplicateOperator
↪  line=9] -> exit=2 score=1 summary=failed=0, errors=1
[20/200] Crossover of [StatementDeleteOperator line=5] + [StatementSwapOperator
↪  lines=4/5] -> exit=2 score=1 summary=failed=0, errors=1
[14/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDeleteOperator
↪  line=9] -> exit=2 score=1 summary=failed=0, errors=1
[16/200] Crossover of [StatementDuplicateOperator line=4] + [StatementSwapOperator
↪  lines=7/8] -> exit=2 score=1 summary=failed=0, errors=1
[3/200] Crossover of [StatementDeleteOperator line=4] + [StatementSwapOperator lines=8/9]
↪  -> exit=2 score=1 summary=failed=0, errors=1
[8/200] Crossover of [StatementDuplicateOperator line=5] + [StatementSwapOperator
↪  lines=9/10] -> exit=2 score=1 summary=failed=0, errors=1
[13/200] Crossover of [StatementDeleteOperator line=5] + [StatementSwapOperator
↪  lines=9/10] -> exit=2 score=1 summary=failed=0, errors=1
[10/200] Crossover of [StatementDeleteOperator line=4] + [StatementDeleteOperator
↪  line=10] -> exit=2 score=1 summary=failed=0, errors=1
[11/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDeleteOperator
↪  line=11] -> exit=2 score=1 summary=failed=0, errors=1
[12/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDeleteOperator
↪  line=1] -> exit=2 score=1 summary=failed=0, errors=1
```

```
[5/200] Crossover of [StatementDeleteOperator line=5] + [StatementSwapOperator lines=8/9]
↪ -> exit=2 score=1 summary=failed=0, errors=1
[7/200] StatementDuplicateOperator line=4 -> exit=2 score=1 summary=failed=0, errors=1
[2/200] Crossover of [StatementDeleteOperator line=4] + [StatementSwapOperator
↪ lines=10/11] -> exit=2 score=1 summary=failed=0, errors=1
[9/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDuplicateOperator
↪ line=7] -> exit=2 score=1 summary=failed=0, errors=1
[32/200] Crossover of [StatementDuplicateOperator line=7] + [StatementSwapOperator
↪ lines=4/5] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[25/200] Crossover of [StatementDeleteOperator line=1] + [StatementDeleteOperator line=9]
↪ -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[31/200] Crossover of [StatementDuplicateOperator line=1] + [StatementSwapOperator
↪ lines=4/5] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[26/200] StatementDeleteOperator line=11 -> exit=1 score=1 summary=failed=1, errors=0,
↪ passed=1
[17/200] Crossover of [StatementDeleteOperator line=1] + [StatementSwapOperator
↪ lines=7/8] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[24/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDuplicateOperator
↪ line=7] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[6/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDeleteOperator
↪ line=11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[15/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDeleteOperator
↪ line=8] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[4/200] StatementDuplicateOperator line=1 -> exit=1 score=1 summary=failed=1, errors=0,
↪ passed=1
[48/200] Crossover of [StatementDeleteOperator line=1] + [StatementSwapOperator
↪ lines=9/10] -> exit=2 score=1 summary=failed=0, errors=1
[46/200] Crossover of [StatementDeleteOperator line=5] + [StatementDeleteOperator
↪ line=11] -> exit=2 score=1 summary=failed=0, errors=1
[52/200] Crossover of [StatementDuplicateOperator line=4] + [StatementSwapOperator
↪ lines=4/5] -> exit=2 score=1 summary=failed=0, errors=1
[59/200] Crossover of [StatementDeleteOperator line=4] + [StatementDeleteOperator line=7]
↪ -> exit=2 score=1 summary=failed=0, errors=1
[57/200] Crossover of [StatementDeleteOperator line=4] + [StatementSwapOperator
↪ lines=7/8] -> exit=2 score=1 summary=failed=0, errors=1
[53/200] StatementDeleteOperator line=5 -> exit=2 score=1 summary=failed=0, errors=1
[61/200] Crossover of [StatementSwapOperator lines=4/5] + [StatementSwapOperator
↪ lines=7/8] -> exit=2 score=1 summary=failed=0, errors=1
[60/200] Crossover of [StatementDeleteOperator line=5] + [StatementDeleteOperator line=9]
↪ -> exit=2 score=1 summary=failed=0, errors=1
[63/200] Crossover of [StatementDeleteOperator line=5] + [StatementSwapOperator
↪ lines=7/8] -> exit=2 score=1 summary=failed=0, errors=1
[33/200] Crossover of [StatementDeleteOperator line=1] + [StatementDeleteOperator
↪ line=10] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[34/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDuplicateOperator
↪ line=9] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[36/200] Crossover of [StatementDuplicateOperator line=5] + [StatementSwapOperator
↪ lines=8/9] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[38/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDuplicateOperator
↪ line=8] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[37/200] StatementSwapOperator lines=8/9 -> exit=1 score=1 summary=failed=1, errors=0,
↪ passed=1
[35/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDuplicateOperator
↪ line=8] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
```

```
[39/200] Crossover of [StatementDuplicateOperator line=5] + [StatementSwapOperator
↪  lines=4/5] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[41/200] StatementSwapOperator lines=4/5 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[71/200] Crossover of [StatementDeleteOperator line=4] + [StatementDeleteOperator
↪  line=11] -> exit=2 score=1 summary=failed=0, errors=1
[42/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDuplicateOperator
↪  line=11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[43/200] Crossover of [StatementDuplicateOperator line=1] + [StatementSwapOperator
↪  lines=7/8] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[45/200] Crossover of [StatementSwapOperator lines=4/5] + [StatementSwapOperator
↪  lines=9/10] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[40/200] Crossover of [StatementDeleteOperator line=1] + [StatementSwapOperator
↪  lines=10/11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[58/200] Crossover of [StatementDeleteOperator line=5] + [StatementSwapOperator
↪  lines=10/11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[47/200] Crossover of [StatementDuplicateOperator line=4] + [StatementSwapOperator
↪  lines=10/11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[55/200] StatementSwapOperator lines=10/11 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[56/200] StatementDuplicateOperator line=10 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[49/200] Crossover of [StatementDuplicateOperator line=4] + [StatementSwapOperator
↪  lines=8/9] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[51/200] StatementDeleteOperator line=8 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[44/200] StatementDuplicateOperator line=9 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[62/200] StatementDeleteOperator line=7 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[54/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDuplicateOperator
↪  line=8] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[50/200] StatementSwapOperator lines=7/8 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[64/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDeleteOperator
↪  line=1] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[68/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDeleteOperator
↪  line=10] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[67/200] Crossover of [StatementDeleteOperator line=4] + [StatementDeleteOperator line=9]
↪  -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[66/200] StatementDeleteOperator line=1 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[69/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDuplicateOperator
↪  line=7] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[65/200] StatementDeleteOperator line=9 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[70/200] Crossover of [StatementDeleteOperator line=5] + [StatementDeleteOperator
↪  line=10] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[72/200] Crossover of [StatementDuplicateOperator line=1] + [StatementSwapOperator
↪  lines=8/9] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[73/200] StatementDuplicateOperator line=11 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[80/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDuplicateOperator
↪  line=10] -> exit=2 score=1 summary=failed=0, errors=1
```

```
[74/200] Crossover of [StatementDuplicateOperator line=1] + [StatementSwapOperator
↪  lines=9/10] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[75/200] StatementDuplicateOperator line=8 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[76/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDeleteOperator
↪  line=9] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[77/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDuplicateOperator
↪  line=10] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[78/200] Crossover of [StatementDeleteOperator line=1] + [StatementSwapOperator
↪  lines=4/5] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[79/200] CompareOperator line=4 replace=>->>= -> exit=1 score=1 summary=failed=1,
↪  errors=0, passed=1
[85/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDuplicateOperator
↪  line=11] -> exit=2 score=1 summary=failed=0, errors=1
[84/200] Crossover of [StatementDuplicateOperator line=5] + [StatementSwapOperator
↪  lines=10/11] -> exit=2 score=1 summary=failed=0, errors=1
[96/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDeleteOperator
↪  line=1] -> exit=2 score=1 summary=failed=0, errors=1
[95/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDeleteOperator
↪  line=11] -> exit=2 score=1 summary=failed=0, errors=1
[89/200] Crossover of [StatementSwapOperator lines=4/5] + [StatementSwapOperator
↪  lines=8/9] -> exit=2 score=1 summary=failed=0, errors=1
[94/200] Crossover of [StatementDeleteOperator line=5] + [StatementDeleteOperator line=7]
↪  -> exit=2 score=1 summary=failed=0, errors=1
[91/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDuplicateOperator
↪  line=10] -> exit=2 score=1 summary=failed=0, errors=1
[82/200] Crossover of [StatementSwapOperator lines=4/5] + [StatementSwapOperator
↪  lines=10/11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[81/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDuplicateOperator
↪  line=11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[99/200] Crossover of [StatementDeleteOperator line=4] + [StatementSwapOperator
↪  lines=9/10] -> exit=2 score=1 summary=failed=0, errors=1
[100/200] StatementDeleteOperator line=4 -> exit=2 score=1 summary=failed=0, errors=1
[101/200] Crossover of [StatementDuplicateOperator line=4] + [StatementDeleteOperator
↪  line=8] -> exit=2 score=1 summary=failed=0, errors=1
[83/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDeleteOperator
↪  line=10] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[86/200] Crossover of [StatementDeleteOperator line=1] + [StatementDeleteOperator
↪  line=11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[88/200] StatementDeleteOperator line=10 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[90/200] StatementDuplicateOperator line=7 -> exit=1 score=1 summary=failed=1, errors=0,
↪  passed=1
[92/200] Crossover of [StatementDuplicateOperator line=7] + [StatementDeleteOperator
↪  line=1] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[97/200] Crossover of [StatementDeleteOperator line=4] + [StatementDeleteOperator line=8]
↪  -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[93/200] Crossover of [StatementDeleteOperator line=1] + [StatementDeleteOperator line=7]
↪  -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[87/200] Crossover of [StatementDuplicateOperator line=1] + [StatementDuplicateOperator
↪  line=9] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[98/200] Crossover of [StatementDeleteOperator line=1] + [StatementDeleteOperator line=8]
↪  -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[102/200] Crossover of [StatementDuplicateOperator line=5] + [StatementDeleteOperator
↪  line=8] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
```

```
[103/200] Crossover of [StatementDuplicateOperator line=1] + [StatementSwapOperator
↪  lines=10/11] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
[104/200] Crossover of [StatementDeleteOperator line=1] + [StatementSwapOperator
↪  lines=8/9] -> exit=1 score=1 summary=failed=1, errors=0, passed=1
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool> mvn test
[INFO] Scanning for projects...
[INFO]
[INFO] -------------------------< com.par:par-tool >--------------------------
[INFO] Building par-tool 1.0-SNAPSHOT
[INFO]    from pom.xml
[INFO] --------------------------------[ jar ]--------------------------------
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ par-tool ---
[INFO] skip non existing resourceDirectory C:\Users\Kevin
↪  Bell\IdeaProjects\PAR-tool\src\main\resources
[INFO]
[INFO] --- compiler:3.13.0:compile (default-compile) @ par-tool ---
[INFO] Nothing to compile - all classes are up to date.
[INFO]
[INFO] --- resources:3.3.1:testResources (default-testResources) @ par-tool ---
[INFO] skip non existing resourceDirectory C:\Users\Kevin
↪  Bell\IdeaProjects\PAR-tool\src\test\resources
[INFO]
[INFO] --- compiler:3.13.0:testCompile (default-testCompile) @ par-tool ---
[INFO] Recompiling the module because of changed source code.
[INFO] Compiling 4 source files with javac [debug target 11] to target\test-classes
[WARNING] system modules path not set in conjunction with -source 11
[INFO]
[INFO] --- surefire:3.2.5:test (default-test) @ par-tool ---
[INFO] Using auto detected provider
↪  org.apache.maven.surefire.junitplatform.JUnitPlatformProvider
[INFO]
[INFO] -------------------------------------------------------
[INFO]  T E S T S
[INFO] -------------------------------------------------------
[INFO] Running com.par.tool.ConfigTest
[INFO] Tests run: 2, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.073 s -- in
↪  com.par.tool.ConfigTest
[INFO] Running com.par.tool.PatternMatcherTest
[INFO] Tests run: 2, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.371 s -- in
↪  com.par.tool.PatternMatcherTest
[INFO] Running com.par.tool.ProcessUtilsTest
[INFO] Tests run: 3, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 2.232 s -- in
↪  com.par.tool.ProcessUtilsTest
[INFO] Running com.par.tool.ScoreTest
[INFO] Tests run: 3, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.009 s -- in
↪  com.par.tool.ScoreTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 10, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] ------------------------------------------------------------------------
[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
```

```
[INFO] Total time:  4.231 s
[INFO] Finished at: 2025-12-04T14:11:17-07:00
[INFO] ------------------------------------------------------------------------
PS C:\Users\Kevin Bell\IdeaProjects\PAR-tool>
```