Evolutionary Computation - Assignment 7 Report

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Problem description

Problem

We were to find a cycle that consisted of exactly 50% of the available nodes, where each node had its own cost along with x and y coordinates. The objective function was a sum of node costs and distances (Euclidean) between each traveled node.

Solution implementation

We have added a new method - Large neighborhood search with two variants (using or not using local search after destroy-repair operators).

- **Large neighborhood search**
  - **Input:**
    - `nodes` : An array of available nodes
    - `costDistanceInfo` : A symmetric matrix of distances and costs between nodes
    - `maxRuntime` : Double representing the maximal runtime of the cycle generator method.
    - `destroyRatio` : Double representing the ratio of nodes to be destroyed in each cycle iteration.
    - `flagLSAfter` : Boolean informing whether to use the Local Search after destroy repair operations.
  - **Output:**
    - An array of new `cycle` node IDs
  - **Function:**

```
FUNCTION generateCycle(start_pos)
    INITIALIZE bestCycle TO Randomly Generated Cycle
    RUN LocalSearch ON bestCycle
    INITIALIZE timePassed TO 0
```

```
    WHILE timePassed < maxRuntime DO
        INITIALIZE currCycle TO a copy of bestCycle
        CALL destroy(currCycle)
        CALL repair(currCycle)

        IF flagLSAfter THEN
            INITIALIZE lsGen AS
LocalSearchGenerator(costDistanceInfo, currCycle)
            SET currCycle TO lsGen.generateCycle(start_pos)
        END IF

        SET currCost TO calculateCycleCost(currCycle)
        IF currCost < bestCost THEN
            SET bestCost TO currCost
            SET bestCycle TO currCycle
        END IF

        SET currTime TO current system time
        SET timePassed TO time difference between currTime and
startTime
    END WHILE
    RETURN bestCycle
END FUNCTION

FUNCTION destroy(cycle)
    INITIALIZE iterations TO (destroyNodeRatio * size of cycle)

    FOR it FROM 0 TO iterations - 1 DO
        INITIALIZE costsAndNodes TO an empty array
        SET prevNodeId TO last element in cycle
        INITIALIZE costSum TO 0

        FOR id FROM 0 TO size of cycle - 1 DO
            SET nextNodeId TO node at index (id + 1) % size of
cycle
            CALCULATE currNodeCost AS (distance from prevNodeId to
id) + (distance from id to nextNodeId) + node cost at id
            ADD (currNodeCost, id) TO costsAndNodes
            INCREMENT costSum BY currNodeCost
            SET prevNodeId TO id
        END FOR

        SORT costsAndNodes by first element (costs)
        DIVIDE first element in costsAndNodes by costSum

        FOR i FROM 1 TO size of costsAndNodes - 1 DO
            DIVIDE costsAndNodes[i].first BY costSum
            ADD costsAndNodes[i-1].first TO costsAndNodes[i].first
        END FOR

        GENERATE random float currPick BETWEEN 0 and 1
```

```
        SET selectedNodeToRemove TO second element of
costsAndNodes[0]
        FOR nodeCostPair IN costsAndNodes DO
            IF nodeCostPair.first > currPick THEN
                SET selectedNodeToRemove TO nodeCostPair.second
                BREAK
            END IF
        END FOR
        REMOVE selectedNodeToRemove FROM cycle
    END FOR
END FUNCTION

FUNCTION repair(cycle)
    INITIALIZE kRegretGenerator AS
KRegretGreedyCycleCombinationGenerator(costDistanceInfo, nodes,
0.5)
    SET cycle TO kregretGenerator.generateCycle(0, cycle)
END FUNCTION
```

Presenting the results

Results presented as minimum, average and maximum of objective function

Presented in a table below, each method and each problem instance is shown.

Out[3]:

Method	TSPA	TSPB
Greedy LS (Edges) on 2-Regret Weighted 200 runs	71509.42 (70571 - 72485)	50033.92 (45855 - 54814)
Iterated LS 20 runs	69256.11 (69095 - 69614)	43634.53 (43448 - 44215)
LNS No LS 20 runs	70097.05 (69336 - 71100)	44849.16 (43961 - 47055)
LNS With LS 20 runs	70020.58 (69373 - 71128)	44481.84 (43845 - 45540)
Multiple start LS 20 runs	71250.74 (70684 - 71957)	45795.84 (45108 - 46295)
Steepest LS (Edges) on 2-Regret Weighted 200 runs	71470.14 (70510 - 72614)	49895.7 (45867 - 54814)

Information regarding running time and iterations of main loop of different methods.

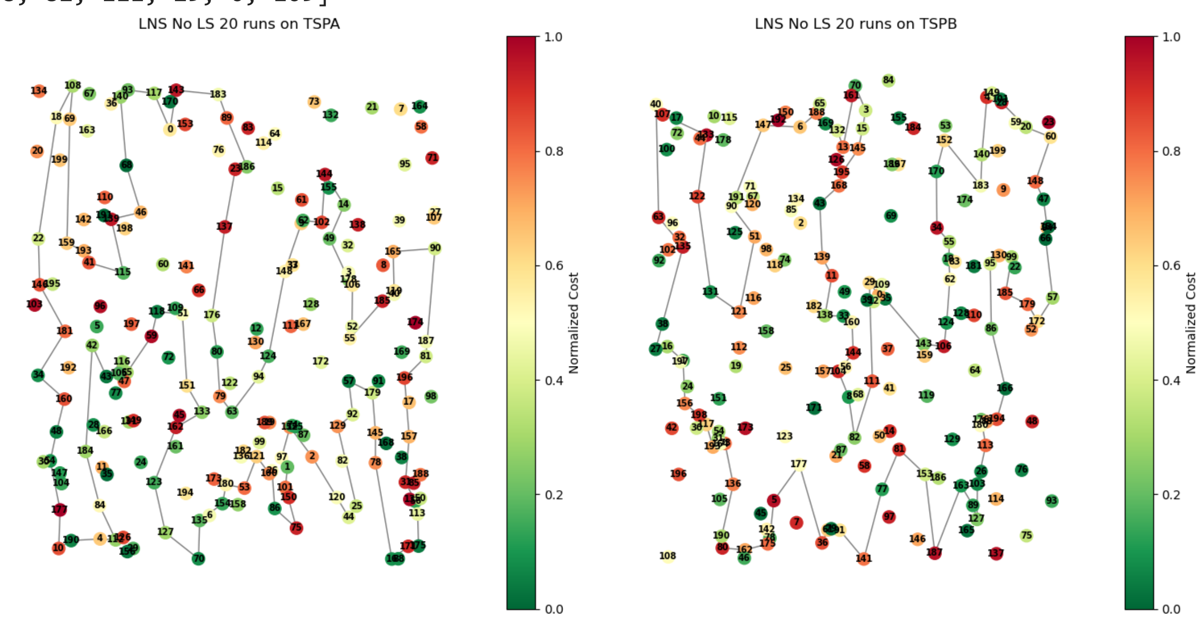
Out[4]:

Method	TSPA	TSPB
Iterated LS	2602.95 (2358 - 2823) runs	2611.65 (2416 - 2886) runs
LNS No LS	4271.3 (4105 - 4412) runs	3747.8 (2524 - 4215) runs
LNS With LS	3460.75 (2903 - 3698) runs	2837.95 (1847 - 3562) runs
Multiple start LS	36404.82 (33524.3 - 38601.8) ms	34441.575 (33030.7 - 38215.2) ms

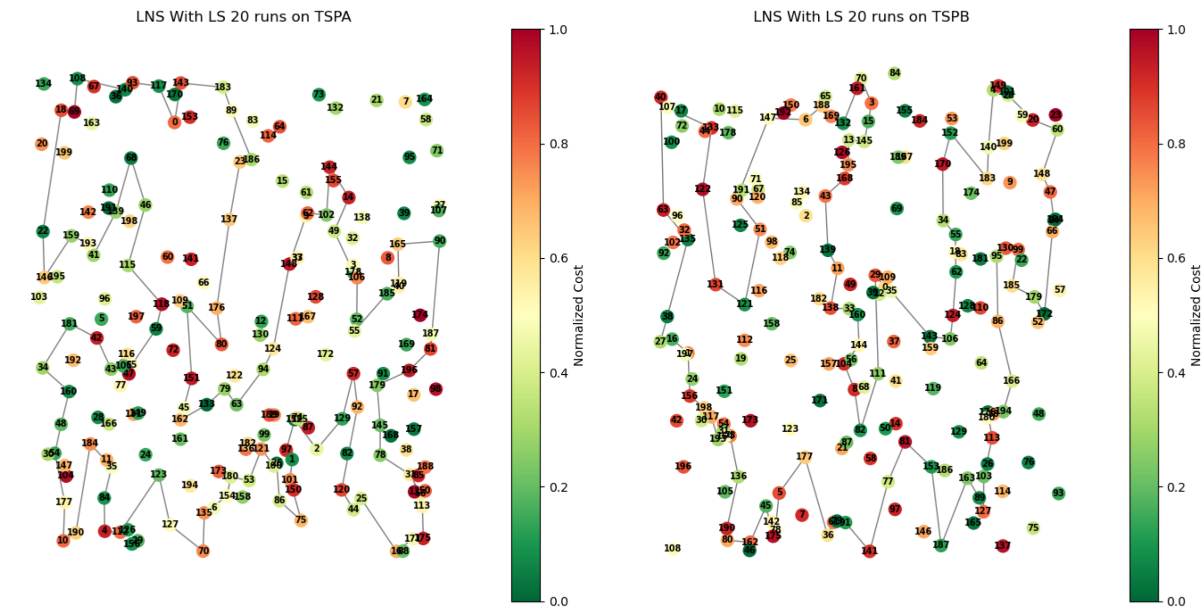
Visualization of the best path for each method

Additionally, a list of node indices is presented.

```
LNS No LS 20 runs
TSPA
[14, 49, 178, 106, 52, 55, 185, 40, 165, 90, 81, 196, 157, 31, 56, 113, 175, 171, 16
, 78, 145, 179, 57, 92, 129, 25, 44, 120, 2, 152, 97, 1, 101, 75, 86, 26, 100, 121,
53, 180, 154, 135, 70, 127, 123, 162, 133, 151, 51, 118, 59, 65, 116, 43, 42, 184, 8
4, 112, 4, 190, 10, 177, 54, 48, 160, 34, 181, 146, 22, 18, 108, 69, 159, 193, 41, 1
15, 139, 46, 68, 140, 93, 117, 0, 143, 183, 89, 186, 23, 137, 176, 80, 79, 63, 94, 1
24, 148, 9, 62, 102, 144]
0 2
TSPB
[35, 143, 106, 124, 62, 18, 55, 34, 170, 152, 183, 140, 4, 149, 28, 20, 60, 148, 47,
94, 66, 57, 172, 179, 185, 99, 130, 95, 86, 166, 194, 176, 113, 103, 127, 89, 163, 1
87, 153, 81, 77, 141, 91, 61, 36, 177, 5, 78, 175, 162, 80, 190, 136, 73, 54, 31, 19
3, 117, 198, 156, 1, 16, 27, 38, 135, 63, 40, 107, 133, 122, 131, 121, 51, 90, 147,
6, 188, 169, 132, 13, 70, 3, 15, 145, 195, 168, 43, 139, 11, 138, 33, 160, 144, 104,
8, 82, 111, 29, 0, 109]
```



```
LNS With LS 20 runs
TSPA
[179, 145, 78, 31, 56, 113, 175, 171, 16, 25, 44, 120, 92, 57, 129, 2, 152, 97, 1, 1
01, 75, 86, 26, 100, 121, 53, 180, 154, 135, 70, 127, 123, 112, 4, 84, 35, 184, 190,
10, 177, 54, 48, 160, 34, 181, 42, 43, 116, 65, 59, 118, 115, 46, 68, 139, 41, 193,
159, 146, 22, 18, 69, 108, 140, 93, 117, 0, 143, 183, 89, 186, 23, 137, 176, 80, 51,
151, 162, 133, 79, 63, 94, 124, 148, 9, 62, 102, 144, 14, 49, 178, 106, 52, 55, 185,
40, 165, 90, 81, 196]
1 3
TSPB
[143, 106, 124, 62, 18, 55, 34, 170, 152, 183, 140, 4, 149, 28, 20, 60, 148, 47, 94,
66, 172, 179, 185, 99, 130, 95, 86, 166, 194, 176, 113, 103, 127, 89, 163, 187, 153,
81, 77, 141, 91, 61, 36, 177, 5, 78, 175, 45, 162, 80, 190, 136, 73, 54, 31, 193, 11
7, 198, 156, 1, 16, 27, 38, 135, 63, 40, 107, 133, 122, 131, 121, 51, 90, 147, 6, 18
8, 169, 132, 70, 3, 15, 145, 13, 195, 168, 43, 139, 11, 138, 33, 160, 144, 104, 8, 8
2, 111, 29, 0, 109, 35]
```



Additional Information

Solution checker

We have checked all of the best solutions via the solution checker provided.

Source code link

The source code is available in a repository here under the Lab7 folder.

Conclusions

LNS methods show a large improvement in terms of iterations that they are able to produce compared to the Iterated Local Search. On the other hand they are unable to produce better results, than ILS. They are able to produce results better than the Basic Steepest and Greedy

Methods with 2-regret and MSLS. The newly created methods strike a balance between exploration and local optimization.

Adding Local Search after each destroy-repair operation improves solution quality while requiring fewer iterations. LNS with Local Search refines the solution more effectively in each step, allowing it to achieve better results despite running fewer iterations compared to LNS without Local Search. This shows the value of combining Local Search with the destroy-repair process for better efficiency and outcomes.

Authors

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