03-local-search

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Github

1 Description of a problem

We are given three columns of integers with a row for each node. The first two columns contain x and y coordinates of the node positions in a plane. The third column contains node costs. The goal is to select exactly 50% of the nodes (if the number of nodes is odd we round the number of nodes to be selected up) and form a Hamiltonian cycle (closed path) through this set of nodes such that the sum of the total length of the path plus the total cost of the selected nodes is minimized.

The distances between nodes are calculated as Euclidean distances rounded mathematically to integer values. The distance matrix should be calculated just after reading an instance and then only the distance matrix (no nodes coordinates) should be accessed by optimization methods to allow instances defined only by distance matrices.

2 Local Search

Function local_search($dataset, distance\_matrix, initial\_solution, strategy, intra\_search$) :

Initialize cost of the initial solution

Set the solution as the initial solution

Identify selected nodes and non-selected nodes

Loop until no improvement can be found :

Search for intra-route neighbors based on intra_search type (node or edge)

Search for inter-route neighbors between solution nodes and non-selected nodes

Combine intra-route and inter-route neighbors into all_neighbors

If there are no improving neighbors :

Exit the loop

If strategy is "greedy" :

Shuffle neighbors and select the first improving neighbor

Else If strategy is "steepest" :

Choose the neighbor with the steepest improvement

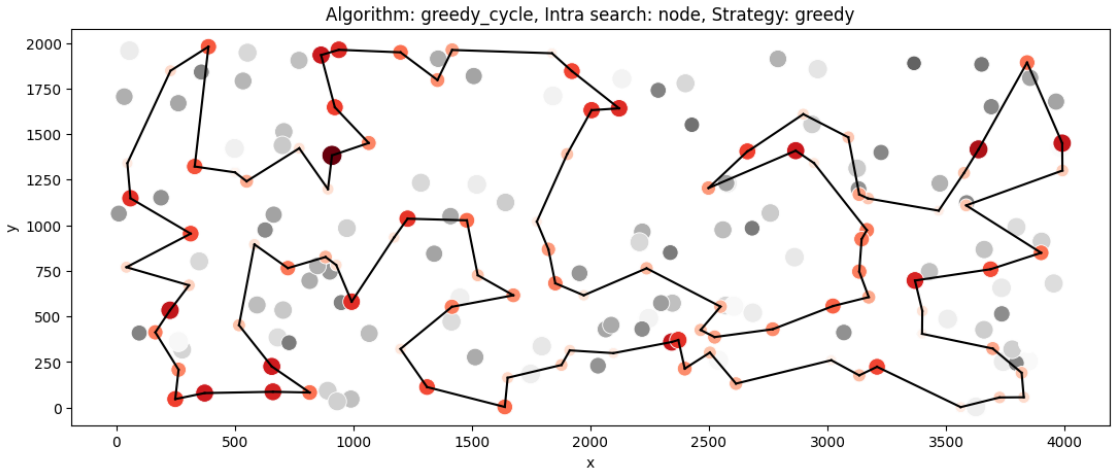
Update solution, selected nodes, and non-selected nodes based on best neighbor

Update cost by adding the improvement of the best neighbor

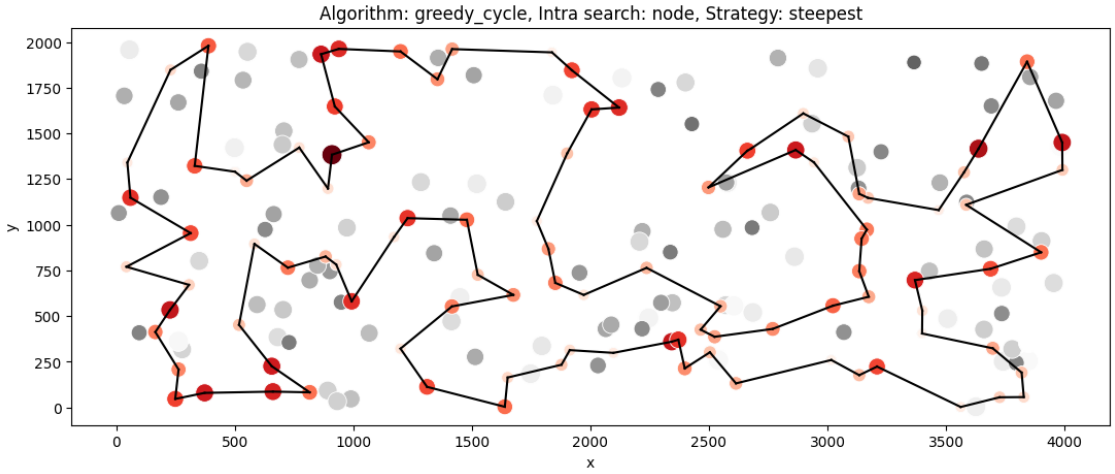
Returnthe final solution as a subset of the dataset

Results on Dataset A

```
Best solution: [198, 115, 139, 41, 193, 159, 108, 18, 22, 146, 181, 34, 160, 48,
54, 177, 10, 190, 4, 112, 84, 184, 42, 43, 116, 65, 149, 59, 118, 51, 151, 133,
162, 123, 127, 70, 135, 154, 180, 53, 100, 26, 86, 101, 75, 120, 44, 25, 16,
171, 175, 113, 31, 78, 145, 179, 196, 81, 40, 90, 27, 164, 39, 165, 185, 106,
178, 14, 144, 62, 9, 148, 102, 49, 52, 55, 57, 92, 129, 2, 1, 97, 152, 94, 63,
79, 80, 176, 137, 23, 186, 89, 183, 143, 0, 117, 93, 140, 68, 46]
Objective function statistics:
minimum = 70564
mean = 71409.285
maximum = 72444
```

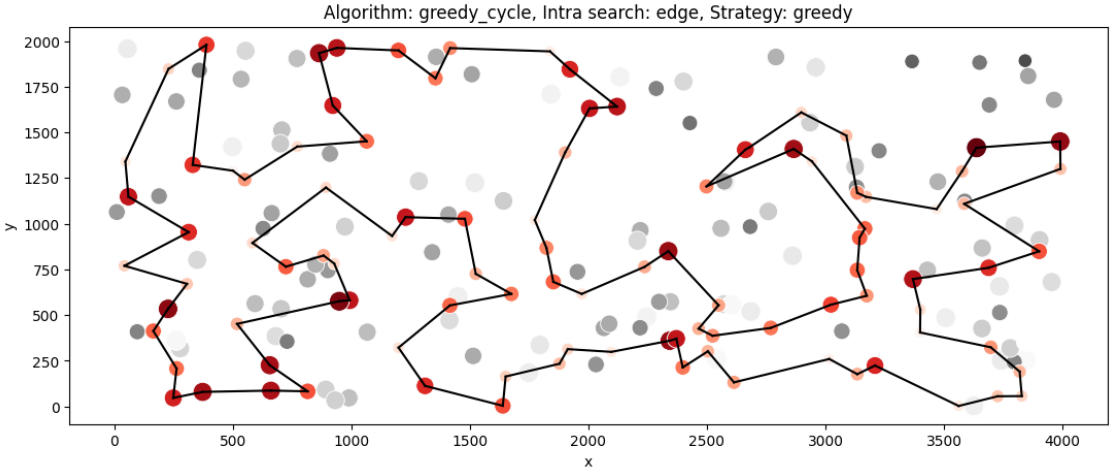


Best solution: [198, 115, 139, 41, 193, 159, 108, 18, 22, 146, 181, 34, 160, 48, 54, 177, 10, 190, 4, 112, 84, 184, 42, 43, 116, 65, 149, 59, 118, 51, 151, 133, 162, 123, 127, 70, 135, 154, 180, 53, 100, 26, 86, 101, 75, 120, 44, 25, 16, 171, 175, 113, 31, 78, 145, 179, 196, 81, 40, 90, 27, 164, 39, 165, 185, 106, 178, 14, 144, 62, 9, 148, 102, 49, 52, 55, 57, 92, 129, 2, 1, 97, 152, 94, 63, 79, 80, 176, 137, 23, 186, 89, 183, 143, 0, 117, 93, 140, 68, 46]
Objective function statistics:
minimum = 70564
mean = 71408.27
maximum = 72444

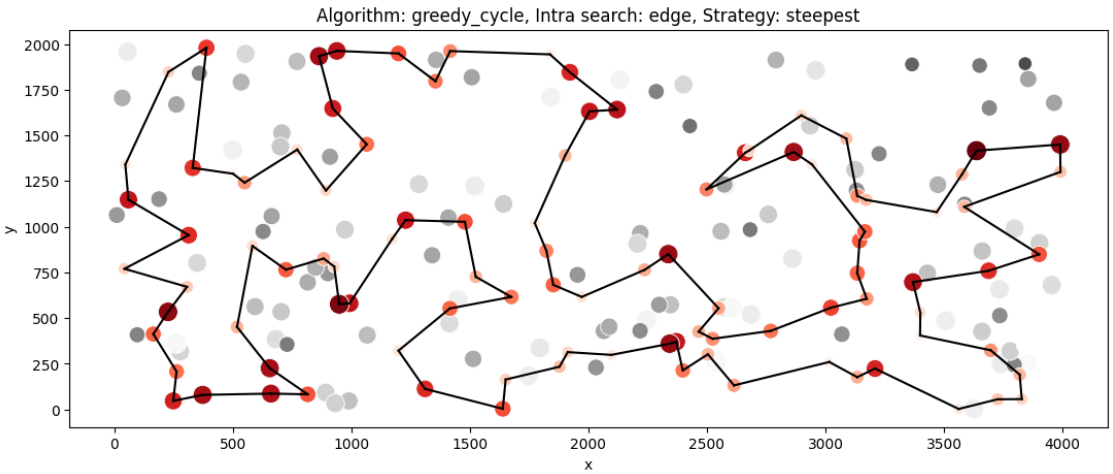


Best solution: [149, 65, 116, 43, 42, 115, 59, 118, 51, 151, 133, 162, 123, 127, 70, 135, 154, 180, 53, 100, 26, 86, 101, 75, 120, 44, 25, 16, 171, 175, 113, 31, 78, 145, 179, 196, 81, 40, 90, 27, 39, 165, 185, 106, 178, 14, 144, 62, 9, 148, 102, 49, 52, 55, 57, 92, 129, 2, 1, 97, 152, 124, 94, 63, 79, 80, 176, 137, 23,

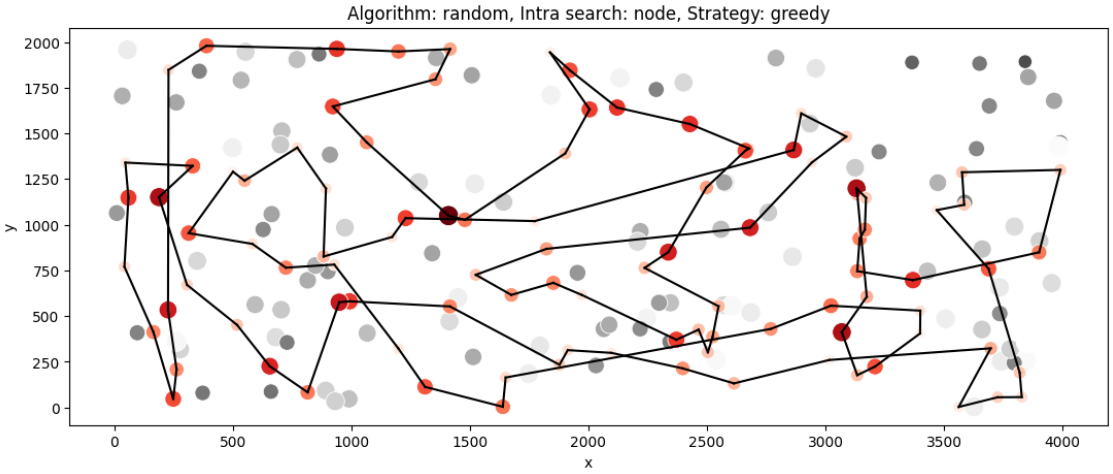
186, 89, 183, 143, 0, 117, 93, 140, 68, 46, 139, 41, 193, 159, 108, 18, 22, 146, 181, 34, 160, 48, 54, 177, 10, 190, 4, 112, 84, 184, 131]
Objective function statistics:
minimum = 70334
mean = 71276.885
maximum = 72378



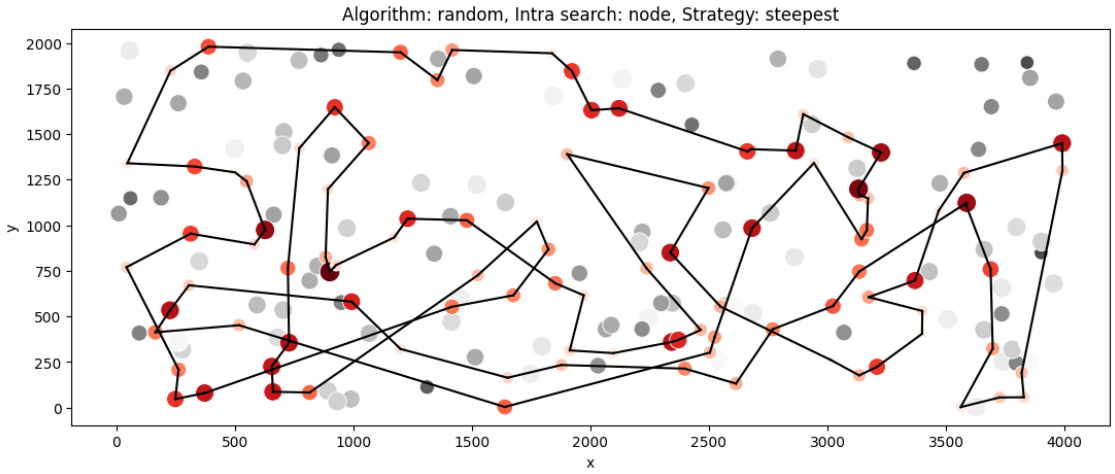
Best solution: [162, 133, 151, 51, 118, 59, 149, 131, 65, 116, 43, 42, 184, 84, 112, 4, 190, 10, 177, 54, 48, 160, 34, 181, 146, 22, 18, 108, 159, 193, 41, 139, 115, 46, 68, 140, 93, 117, 0, 143, 183, 89, 186, 23, 137, 176, 80, 79, 63, 94, 124, 152, 97, 1, 2, 129, 92, 57, 55, 52, 49, 102, 148, 9, 62, 144, 14, 178, 106, 185, 165, 39, 27, 90, 40, 81, 196, 179, 145, 78, 31, 113, 175, 171, 16, 25, 44, 120, 75, 101, 86, 26, 100, 53, 180, 154, 135, 70, 127, 123]
Objective function statistics:
minimum = 70174
mean = 71259.05
maximum = 72378



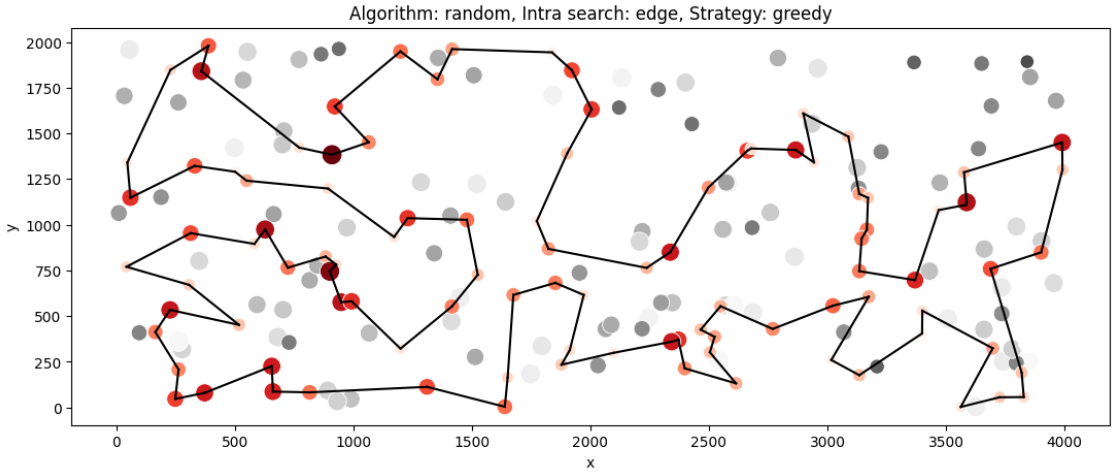
Best solution: [55, 57, 179, 81, 90, 165, 40, 185, 196, 113, 175, 171, 16, 31, 120, 75, 86, 53, 180, 154, 162, 149, 131, 112, 84, 184, 160, 195, 159, 22, 146, 34, 54, 10, 177, 48, 18, 108, 93, 117, 143, 0, 68, 46, 109, 51, 137, 23, 183, 89, 186, 15, 62, 9, 148, 124, 94, 152, 1, 101, 97, 26, 63, 79, 133, 151, 80, 167, 49, 14, 144, 102, 176, 118, 59, 116, 115, 139, 41, 193, 181, 42, 43, 65, 123, 127, 70, 135, 2, 129, 145, 78, 25, 44, 82, 92, 178, 3, 106, 52]
Objective function statistics:
minimum = 79361
mean = 86019.175
maximum = 94279



Best solution: [23, 89, 183, 143, 0, 117, 108, 18, 22, 159, 193, 41, 5, 42, 181, 34, 177, 10, 190, 162, 133, 80, 176, 151, 112, 4, 84, 35, 43, 139, 68, 46, 115, 116, 47, 65, 59, 118, 51, 79, 63, 180, 53, 100, 26, 97, 94, 137, 148, 124, 152, 120, 44, 25, 78, 145, 92, 179, 185, 165, 27, 90, 113, 175, 171, 16, 31, 196, 40, 119, 57, 129, 2, 75, 86, 154, 135, 123, 149, 160, 48, 54, 184, 70, 101, 1, 167, 49, 55, 52, 106, 178, 3, 138, 14, 144, 102, 62, 9, 186]
Objective function statistics:
minimum = 80496
mean = 88282.39
maximum = 97239

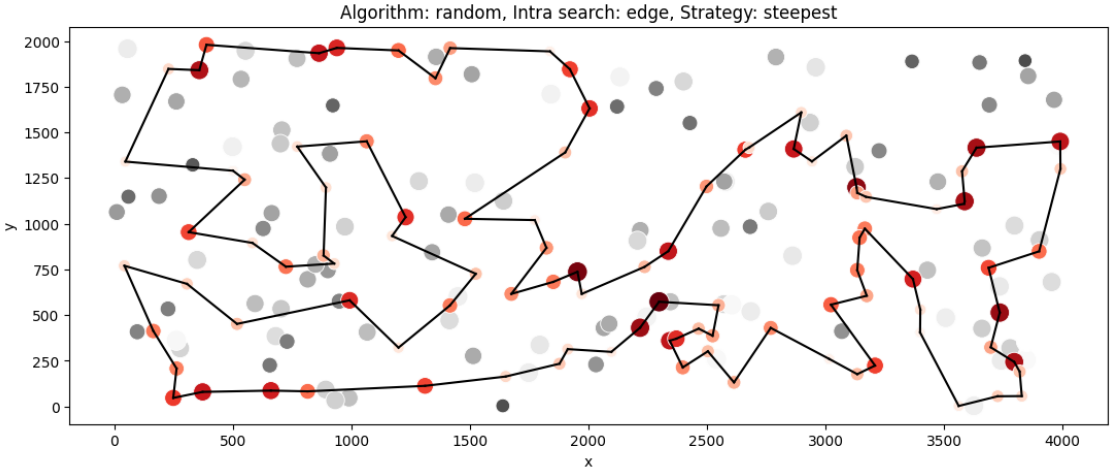


Best solution: [129, 2, 152, 97, 1, 101, 75, 86, 26, 100, 53, 154, 180, 63, 79, 133, 135, 70, 127, 112, 4, 84, 190, 10, 177, 54, 48, 184, 160, 34, 181, 42, 5, 43, 116, 65, 47, 131, 149, 123, 162, 151, 51, 118, 59, 115, 41, 193, 159, 146, 22, 18, 108, 69, 139, 198, 46, 68, 117, 0, 143, 183, 89, 23, 137, 176, 80, 94, 124, 148, 9, 62, 102, 49, 144, 14, 178, 106, 52, 55, 57, 179, 185, 40, 119, 165, 27, 90, 81, 196, 113, 175, 171, 16, 31, 145, 78, 44, 120, 92]
Objective function statistics:
minimum = 71536
mean = 73930.555
maximum = 76814



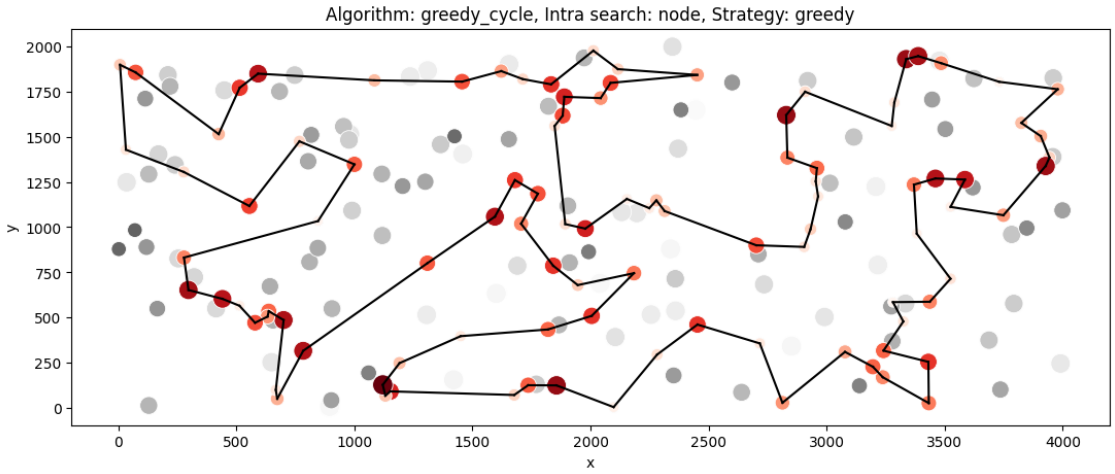
Best solution: [148, 9, 62, 144, 102, 49, 14, 3, 178, 106, 185, 40, 119, 165, 39, 27, 90, 81, 196, 157, 31, 56, 113, 175, 171, 16, 78, 145, 179, 52, 55, 57, 92, 129, 25, 44, 120, 2, 75, 101, 86, 100, 26, 97, 1, 152, 189, 121, 53, 180, 154, 135, 127, 112, 4, 190, 10, 177, 54, 34, 160, 184, 149, 123, 162, 151, 59,

118, 46, 139, 115, 116, 65, 43, 42, 181, 41, 193, 22, 18, 69, 108, 140, 93, 117, 0, 143, 183, 89, 23, 137, 51, 176, 80, 133, 79, 122, 63, 94, 124]
Objective function statistics:
minimum = 72046
mean = 74033.715
maximum = 78801

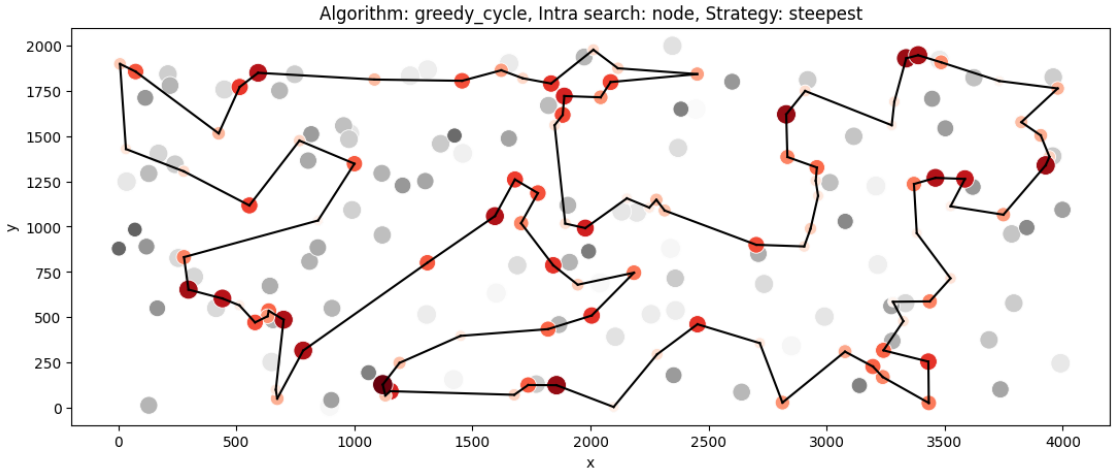


Results on Dataset B

Best solution: [4, 149, 28, 20, 60, 148, 47, 94, 66, 179, 185, 99, 130, 95, 86, 166, 194, 176, 113, 103, 114, 137, 127, 89, 163, 187, 153, 81, 77, 141, 91, 61, 36, 78, 175, 142, 5, 177, 21, 82, 111, 8, 104, 138, 11, 139, 182, 25, 136, 80, 190, 73, 54, 31, 193, 117, 198, 156, 1, 121, 51, 90, 131, 135, 63, 40, 107, 122, 133, 10, 147, 6, 188, 169, 132, 70, 3, 155, 15, 145, 13, 195, 168, 33, 160, 29, 0, 109, 35, 143, 106, 124, 62, 18, 55, 34, 170, 152, 183, 140]
Objective function statistics:
minimum = 45193
mean = 46549.125
maximum = 47677

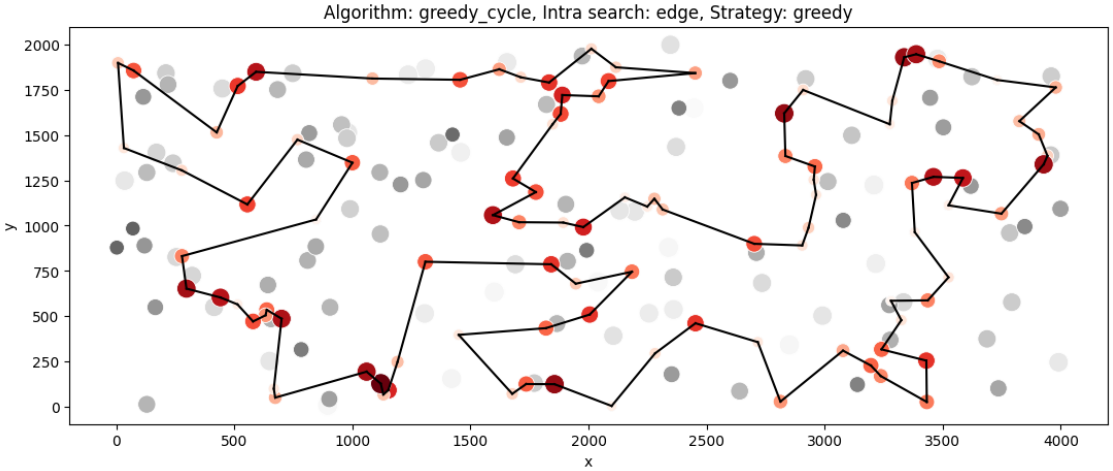


Best solution: [4, 149, 28, 20, 60, 148, 47, 94, 66, 179, 185, 99, 130, 95, 86, 166, 194, 176, 113, 103, 114, 137, 127, 89, 163, 187, 153, 81, 77, 141, 91, 61, 36, 78, 175, 142, 5, 177, 21, 82, 111, 8, 104, 138, 11, 139, 182, 25, 136, 80, 190, 73, 54, 31, 193, 117, 198, 156, 1, 121, 51, 90, 131, 135, 63, 40, 107, 122, 133, 10, 147, 6, 188, 169, 132, 70, 3, 155, 15, 145, 13, 195, 168, 33, 160, 29, 0, 109, 35, 143, 106, 124, 62, 18, 55, 34, 170, 152, 183, 140]
Objective function statistics:
minimum = 45193
mean = 46537.475
maximum = 47682

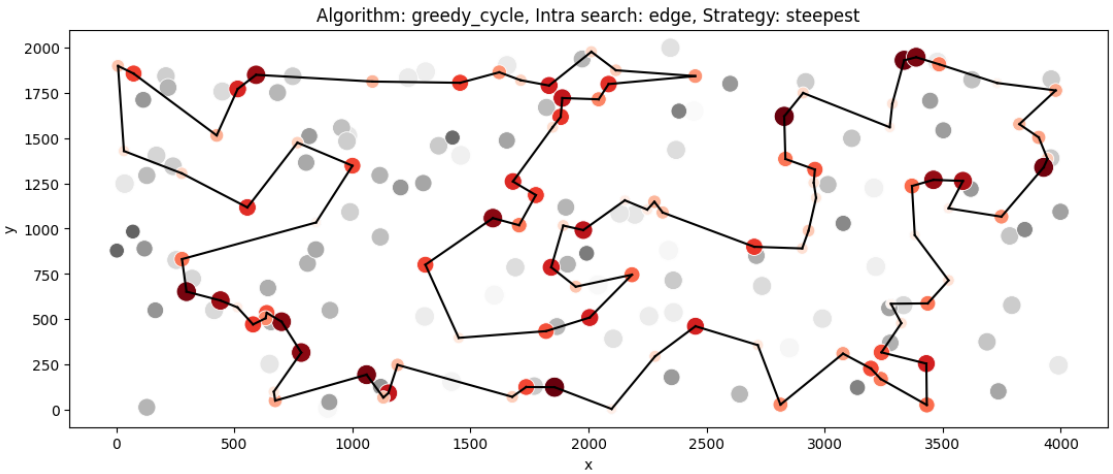


Best solution: [60, 148, 47, 94, 66, 179, 185, 99, 130, 95, 86, 166, 194, 176, 113, 103, 114, 137, 127, 89, 163, 187, 153, 81, 77, 141, 91, 61, 36, 177, 21, 82, 111, 8, 104, 25, 5, 78, 175, 142, 45, 80, 190, 73, 54, 31, 193, 117, 198, 156, 1, 121, 51, 90, 131, 135, 63, 40, 107, 122, 133, 10, 147, 6, 188, 169, 132,

70, 3, 155, 15, 145, 13, 195, 168, 139, 11, 182, 138, 33, 160, 29, 0, 109, 35, 143, 106, 124, 62, 18, 55, 34, 170, 152, 183, 140, 4, 149, 28, 20]
Objective function statistics:
minimum = 44675
mean = 45788.065
maximum = 47432



Best solution: [4, 149, 28, 20, 60, 148, 47, 94, 66, 179, 185, 99, 130, 95, 86, 166, 194, 176, 113, 103, 114, 137, 127, 89, 163, 187, 153, 81, 77, 141, 91, 61, 36, 5, 78, 175, 45, 80, 190, 136, 73, 54, 31, 193, 117, 198, 156, 1, 121, 51, 90, 131, 135, 63, 40, 107, 122, 133, 10, 147, 6, 188, 169, 132, 70, 3, 155, 15, 145, 13, 195, 168, 139, 11, 138, 182, 25, 177, 21, 82, 111, 8, 104, 33, 160, 29, 0, 109, 35, 143, 106, 124, 62, 18, 55, 34, 170, 152, 183, 140]
Objective function statistics:
minimum = 44472
mean = 45564.175
maximum = 47045



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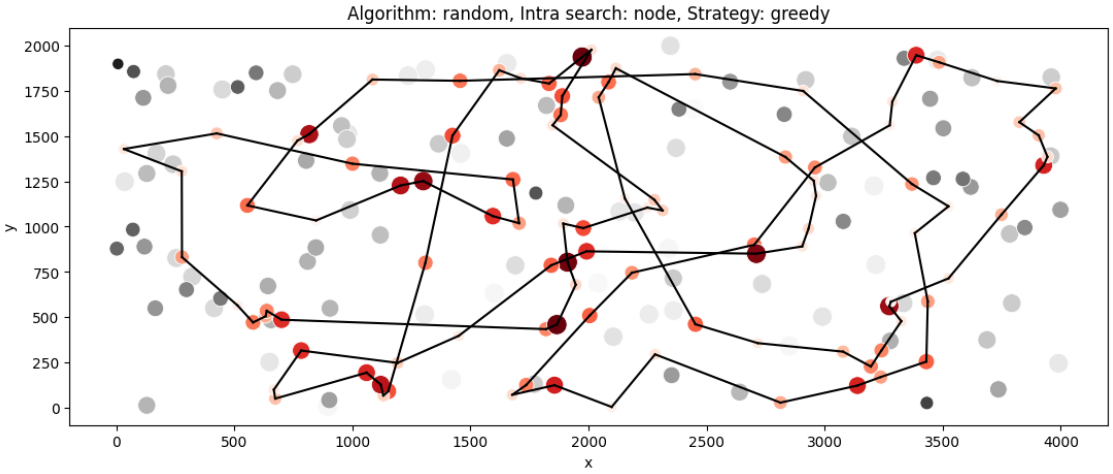
Best solution: [3, 15, 145, 29, 81, 153, 163, 89, 103, 113, 180, 176, 166, 179,
66, 94, 47, 148, 60, 20, 28, 149, 140, 183, 55, 143, 111, 82, 61, 36, 91, 141,
77, 187, 165, 127, 114, 194, 86, 185, 95, 152, 155, 6, 147, 191, 90, 131, 121,
118, 74, 182, 138, 139, 51, 122, 63, 135, 1, 117, 193, 31, 54, 73, 21, 87, 8,
56, 33, 160, 0, 35, 109, 168, 195, 13, 70, 161, 132, 169, 188, 134, 25, 78, 175,
142, 45, 80, 190, 136, 5, 177, 104, 144, 159, 106, 124, 62, 18, 34]
Objective function statistics:
minimum = 54745
mean = 60805.595
maximum = 67472
```

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Best solution: [3, 155, 34, 55, 18, 62, 11, 139, 182, 138, 33, 160, 144, 104, 8,
82, 21, 25, 121, 125, 90, 131, 1, 117, 54, 31, 193, 190, 80, 45, 61, 91, 77, 81,
106, 124, 176, 180, 88, 194, 86, 95, 130, 148, 60, 20, 28, 149, 140, 183, 152,
170, 109, 29, 0, 35, 153, 165, 89, 127, 137, 187, 141, 36, 175, 78, 5, 177, 111,
143, 128, 185, 179, 47, 94, 66, 57, 172, 166, 113, 103, 163, 145, 195, 168, 132,
169, 188, 6, 134, 51, 191, 122, 135, 63, 40, 107, 133, 147, 70]
Objective function statistics:
minimum = 55783
mean = 62911.32
maximum = 71844
```
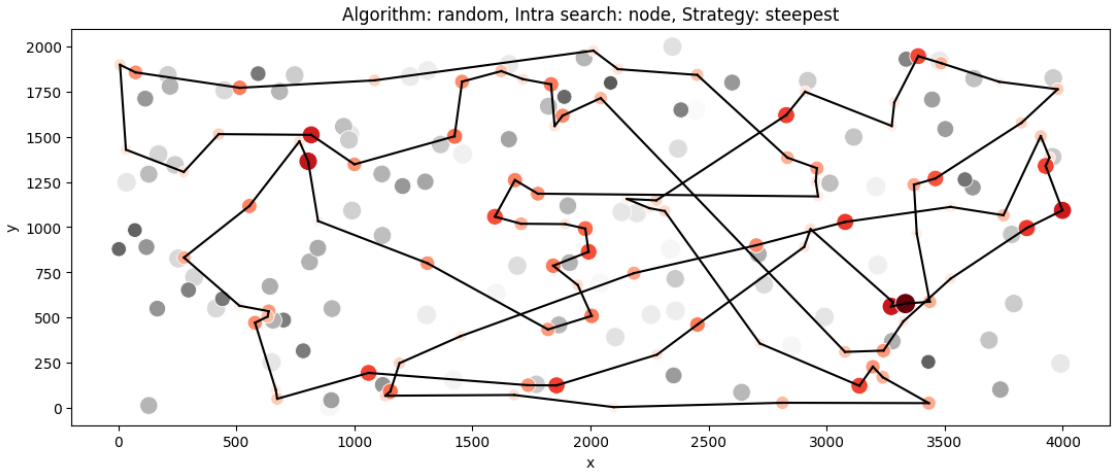
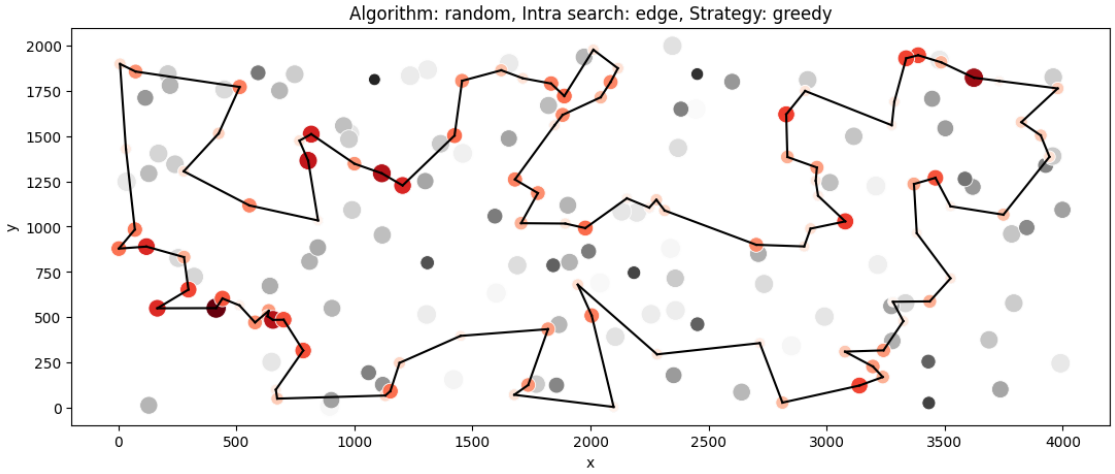
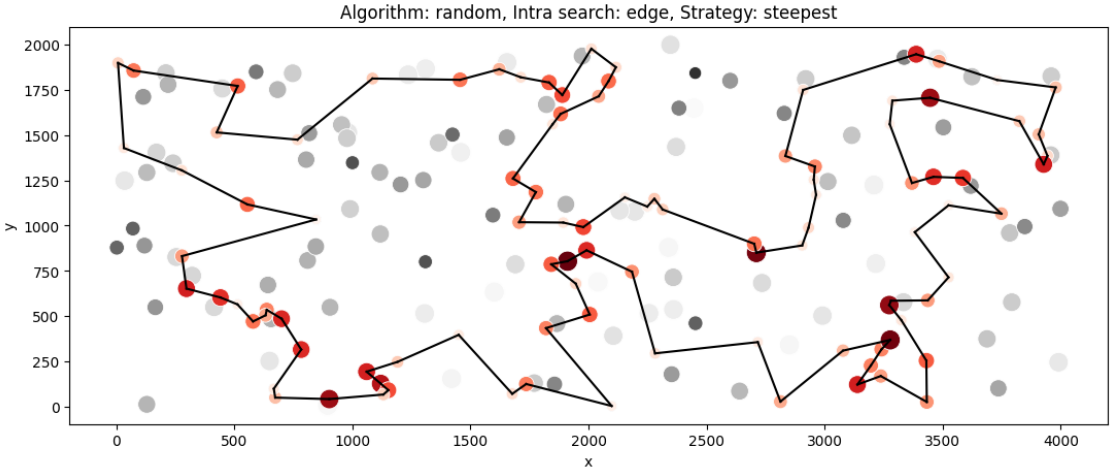



Best solution: [141, 82, 8, 77, 153, 187, 165, 127, 89, 163, 103, 113, 176, 194, 166, 86, 95, 130, 185, 179, 94, 47, 148, 60, 20, 59, 28, 149, 4, 140, 183, 152, 170, 34, 55, 18, 62, 128, 124, 106, 143, 35, 109, 0, 29, 160, 33, 138, 11, 139, 168, 195, 145, 15, 3, 70, 13, 132, 169, 188, 6, 134, 118, 98, 51, 191, 90, 125, 121, 131, 135, 122, 133, 107, 40, 63, 38, 27, 16, 1, 156, 42, 30, 198, 117, 193, 54, 31, 164, 73, 136, 190, 80, 175, 78, 5, 177, 21, 61, 36]
Objective function statistics:
minimum = 45876
mean = 48453.8
maximum = 51449



Best solution: [159, 106, 124, 62, 18, 55, 34, 152, 149, 28, 20, 60, 47, 94, 66, 148, 199, 140, 183, 95, 130, 99, 179, 185, 86, 166, 194, 176, 180, 113, 114, 137, 127, 165, 89, 103, 26, 163, 187, 153, 77, 111, 144, 56, 104, 8, 82, 21, 141, 61, 36, 177, 5, 45, 142, 78, 175, 162, 80, 190, 136, 73, 54, 31, 193, 117,

```
198, 156, 1, 121, 131, 135, 63, 40, 107, 133, 122, 90, 147, 6, 188, 169, 132,
13, 70, 3, 15, 145, 195, 168, 139, 11, 138, 33, 160, 29, 0, 109, 35, 143]
Objective function statistics:
minimum = 45393
mean = 48264.78
maximum = 50697
```



3 Summary

	Dataset A			Dataset B		\
	min	mean	max	min	mean	
greedy_cycle_edge_steepest	70174.0	71259.050	72378.0	44472.0	45564.175	
greedy_cycle_edge_greedy	70334.0	71276.885	72378.0	44675.0	45788.065	
greedy_cycle_node_steepest	70564.0	71408.270	72444.0	45193.0	46537.475	
greedy_cycle_node_greedy	70564.0	71409.285	72444.0	45193.0	46549.125	
greedy_cycle	71263.0	72071.915	73154.0	45312.0	46903.730	
random_cycle_edge_greedy	71536.0	73930.555	76814.0	45876.0	48453.800	
random_cycle_edge_steepest	72046.0	74033.715	78801.0	45393.0	48264.780	
random_node_greedy	79361.0	86019.175	94279.0	54745.0	60805.595	
random_node_steepest	80496.0	88282.390	97239.0	55783.0	62911.320	

	max
greedy_cycle_edge_steepest	47045.0
greedy_cycle_edge_greedy	47432.0
greedy_cycle_node_steepest	47682.0
greedy_cycle_node_greedy	47677.0
greedy_cycle	48623.0
random_cycle_edge_greedy	51449.0
random_cycle_edge_steepest	50697.0

random_node_greedy	67472.0
random_node_steepest	71844.0

4 Conclusion

Local search applied on top of the solution identified by the greedy cycle resulted so far in the best metrics observed. The results of random solution local search are as well pretty decent. However, running LS from scratch may be costly, regardless of the optimizations. On my it took ~15 mins for 200 iterations per dataset and configuration.

Edge type of intra search has shown a bit better results, however, I assume, we have not reasons to split configuration, except for experimental reasons and could search for both types of neighbors at once in practice.