



Genetic algorithms

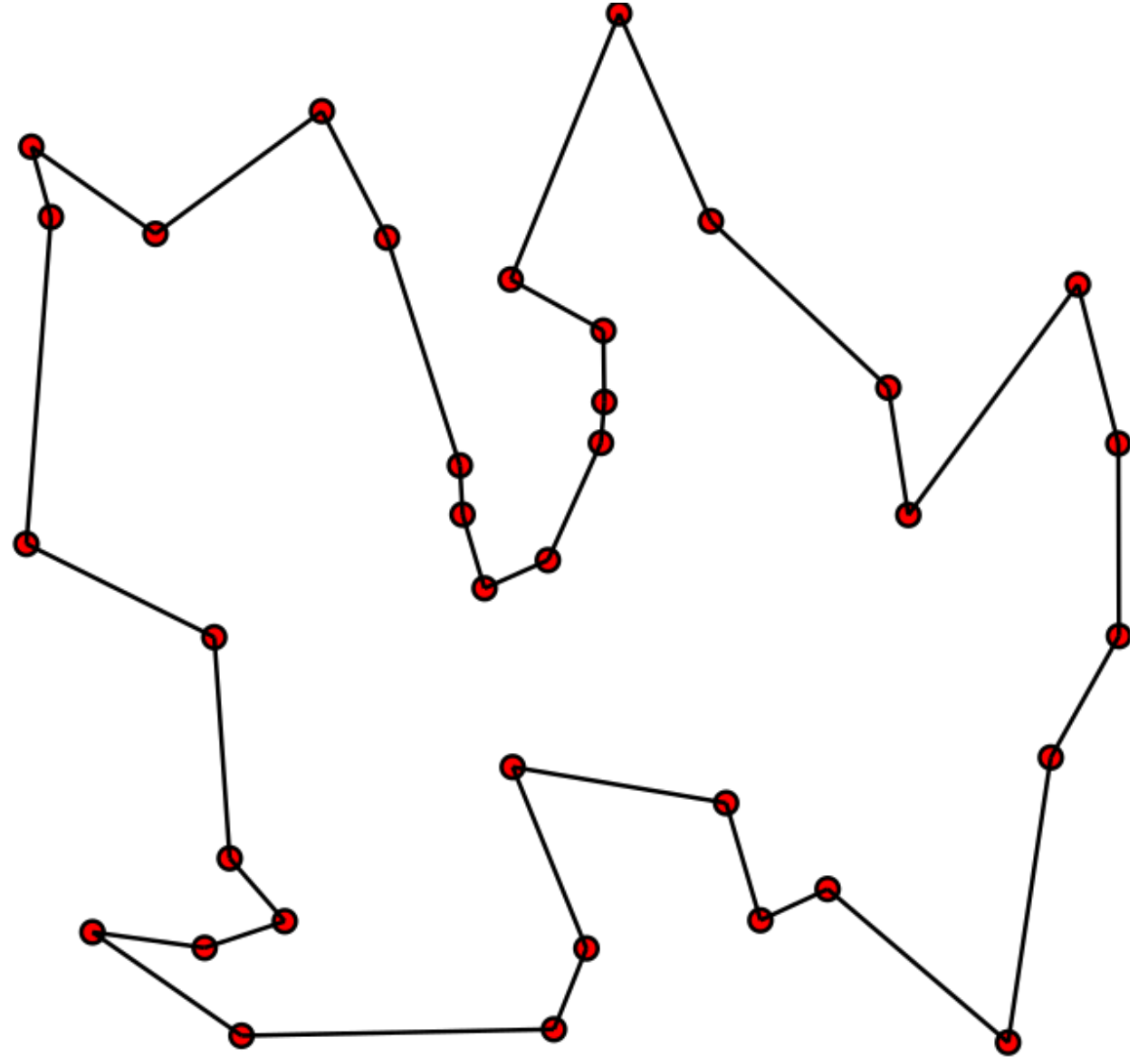
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Travelling salesman problem, TSP

Knowing the list of cities and the distances between them, one must find the shortest possible route that connects all the cities, starts and ends at a specified point, and passes through each city only once.

Complexity $O(n!)$



Representation

	1	2	3	4	5	6	7	8
1	0	12	19	31	22	17	23	12
2	12	0	15	37	21	28	35	22
3	19	15	0	50	36	35	35	21
4	31	37	50	0	20	21	37	38
5	22	21	36	20	0	25	40	33
6	17	28	35	21	25	0	16	18
7	23	35	35	37	40	16	0	14
8	12	22	21	38	33	18	14	0

④ ⑤ ⑦ ③ ① ② ⑥ ⑧
③ ① ⑦ ⑤ ⑥ ④ ② ⑧

STSP (symmetrical)

Selection

Fitness function = $1 / \text{total route length}$

Shorter route -> higher fitness

- Roulette method
- Tournament method

Crossovers (blind)

Parents

1	2	3	4	5	6	7	8	9
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9	8	7	6	5	4	3	2	1
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Offspring

					6	7	8	
--	--	--	--	--	---	---	---	--

9	5	4	3	2	6	7	8	1
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OX (Ordered Crossover)

4	5	7	3	1	2	6	8
3	1	7	5	6	4	2	8

a) parents

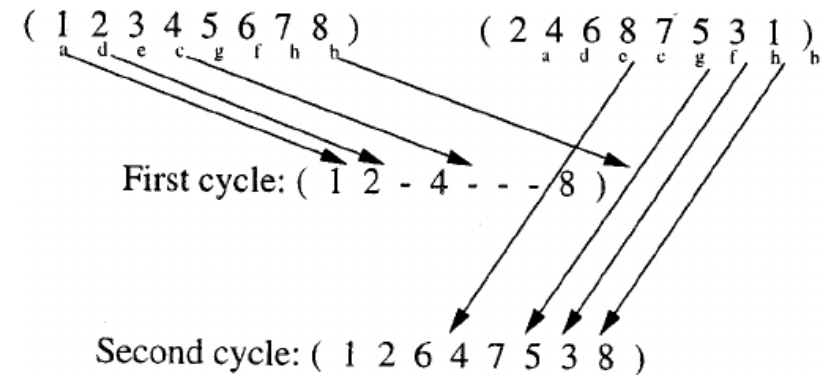
4	5	7	3	1	2	6	8
3	1	7	5	6	4	2	8

b) selects arbitrary points

4	3	7	5	6	2	1	8
5	6	7	3	1	4	2	8

c) children

PMX (Partially Matched Crossover)



CX (Cycle Crossover)

Crossovers (known distance between cities)

father:	4	5	7	3	2	1	6	8
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mother:	5	1	7	3	6	2	4	8
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In each step, four neighbors of recent selected node are considered and which is closer to it is selected.
2, 6, 5 and 7 are neighbors of 1 and 2 is closer to it so is copied to child.

GX (Greedy Crossover)

father:	4	5	7	3	1	2	6	8
mother:	3	1	7	5	6	4	2	8
		↑		↑				
child:	7							

father:	4	5	7	3	1	2	6	8
mother:	3	1	7	5	6	4	2	8
		↑		↑				
child:	7		1					

UHX (Unnamed Heuristic Crossover)

Step 1: Start from 'First Node' of the parent 1 (i.e., current node $p = \text{parent1}(1)$).

Step 2: Sequentially search both of the parent chromosomes and consider The first 'legitimate node' (the node that is not yet visited) appeared after 'node p' in each parent. If no 'legitimate node' after node p is present in any of the parent, search sequentially the nodes from parent 1 and parent 2 (the first 'legitimate node' that is not yet visited from parent1 and parent2), and go to Step 3.

Step 3: Suppose the 'Node α ' and the 'Node β ' are found in 1st and 2nd parent respectively, then for selecting the next node go to Step 4.

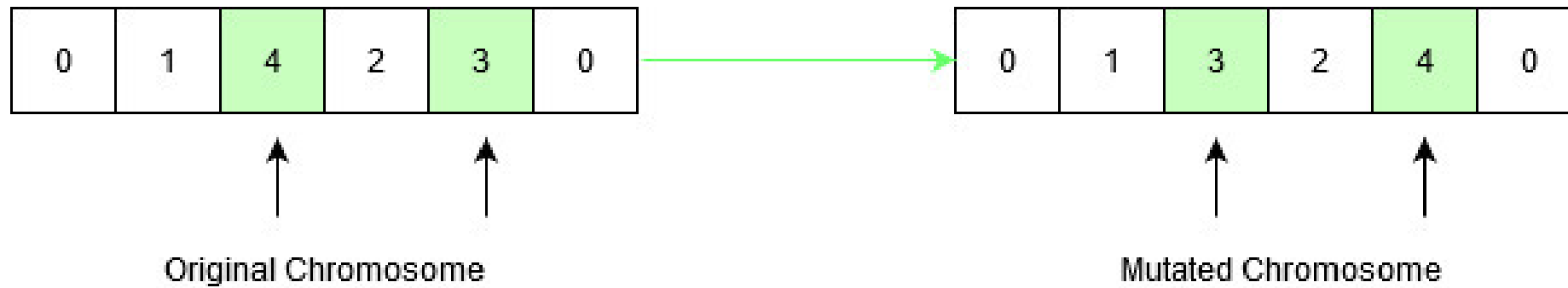
Step 4: If $C_{p\alpha} < C_{p\beta}$, then select 'Node α ', otherwise, 'Node β ' as the next node and concatenate it to the partially constructed offspring chromosome. If the offspring is a complete chromosome, then stop, otherwise, rename the present node as 'Node p' and go to Step 2.

MSCX (Modified Sequential Constructive Crossover)

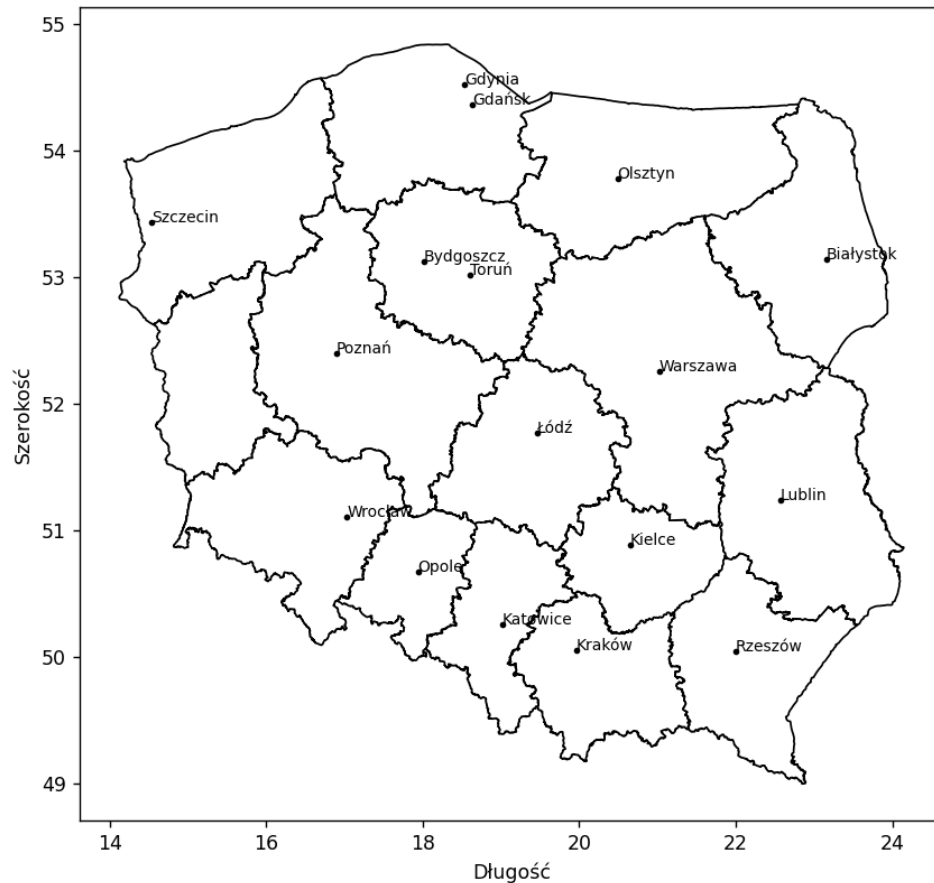
<https://arxiv.org/pdf/2001.11590.pdf>

<https://arxiv.org/ftp/arxiv/papers/1504/1504.02590.pdf>

Mutation



Map of Poland



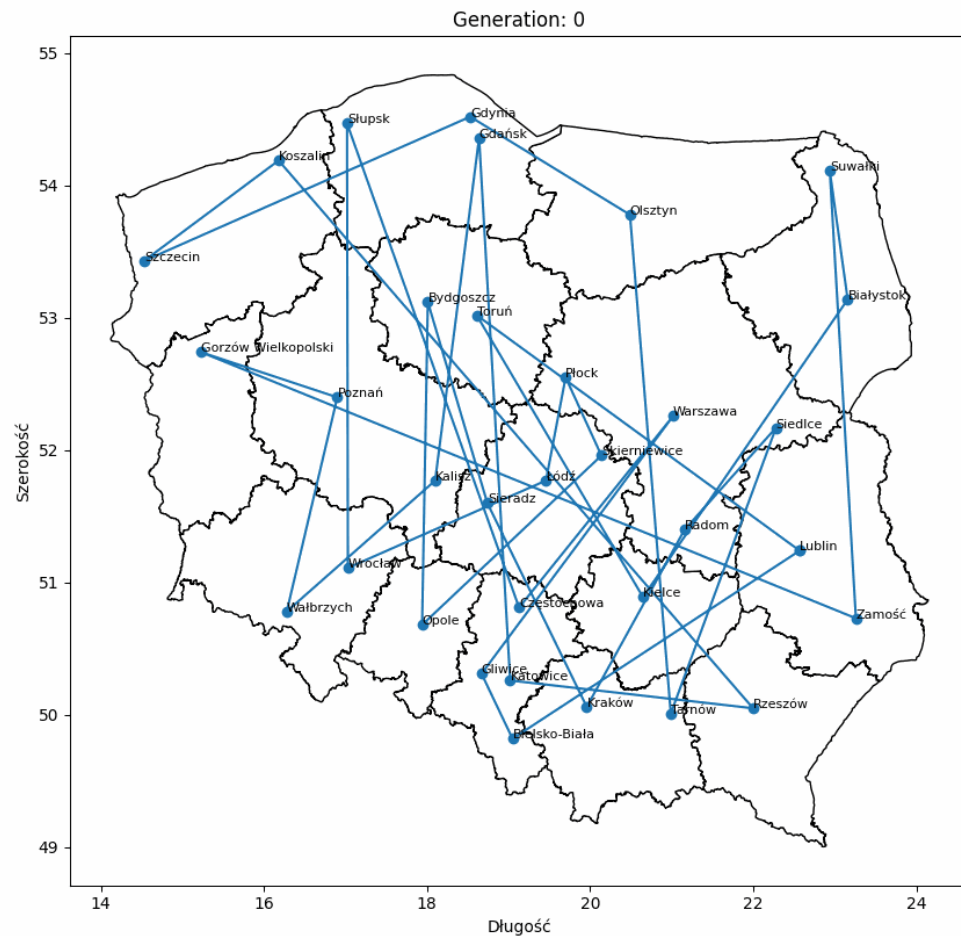
Cities:

http://cybermoon.pl/wiedza/wspolrzedne_polskich_miast.html

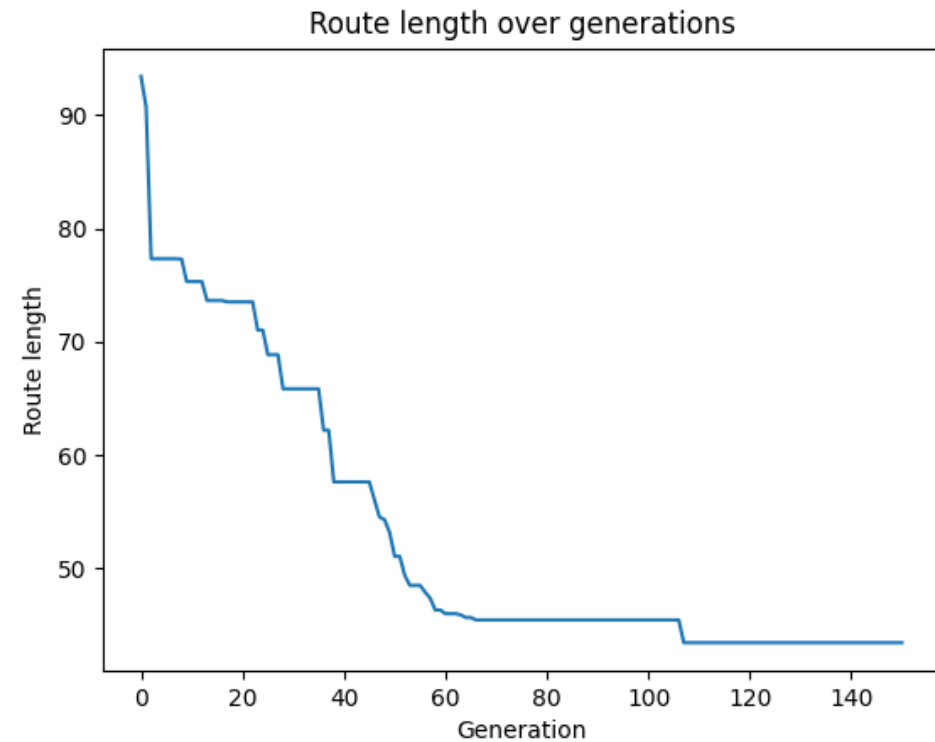
Borders:

<https://www.geoportal.gov.pl/pl/dane/panstwowy-rejestr-granic-prg/>

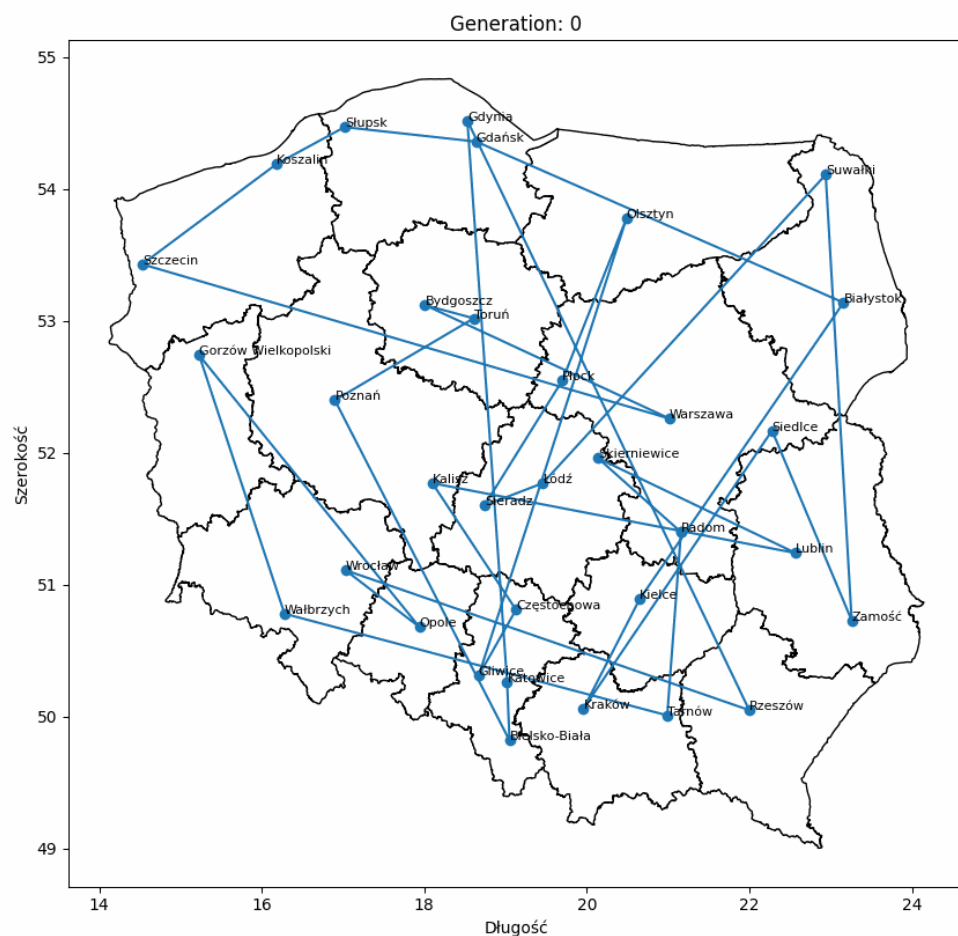
Results - visualization



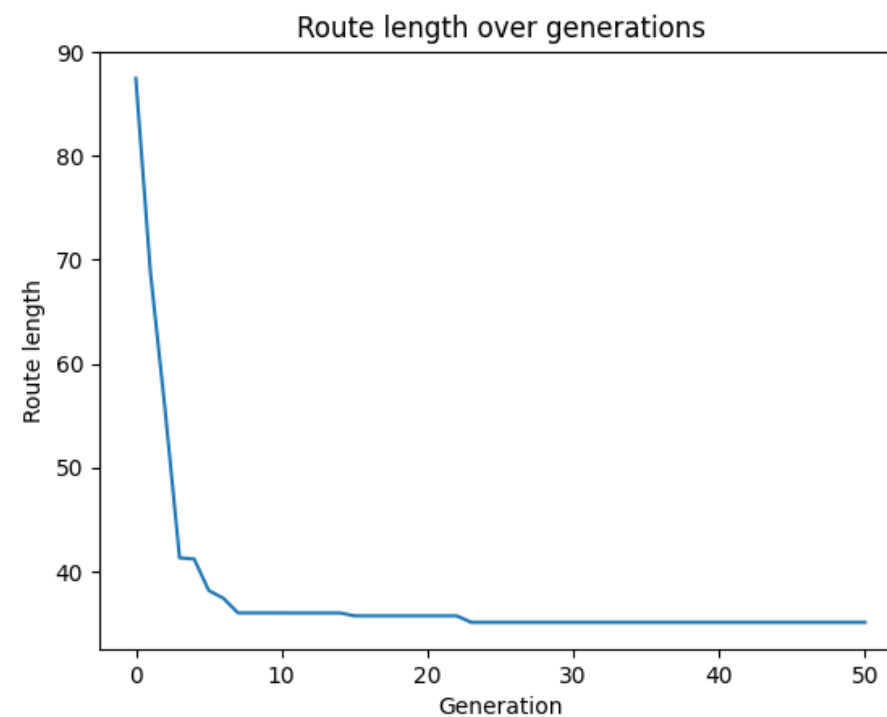
PMX – 40 cities



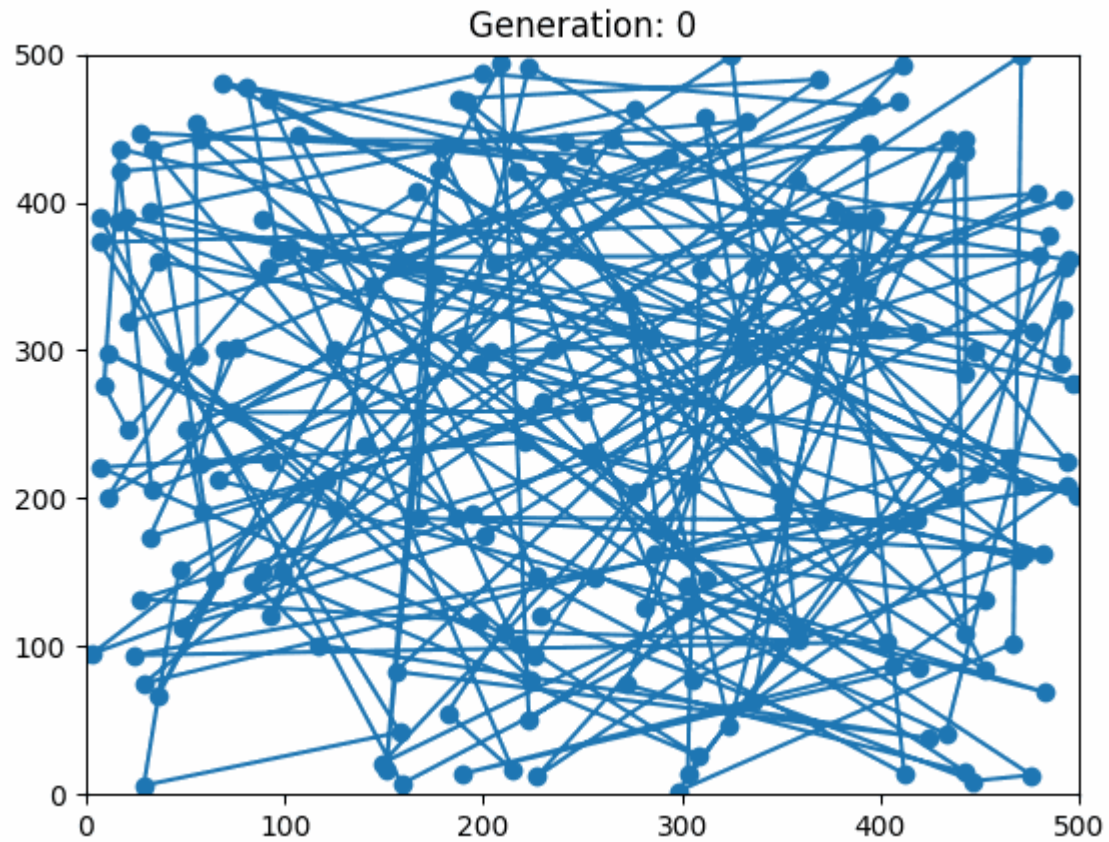
Results - visualization



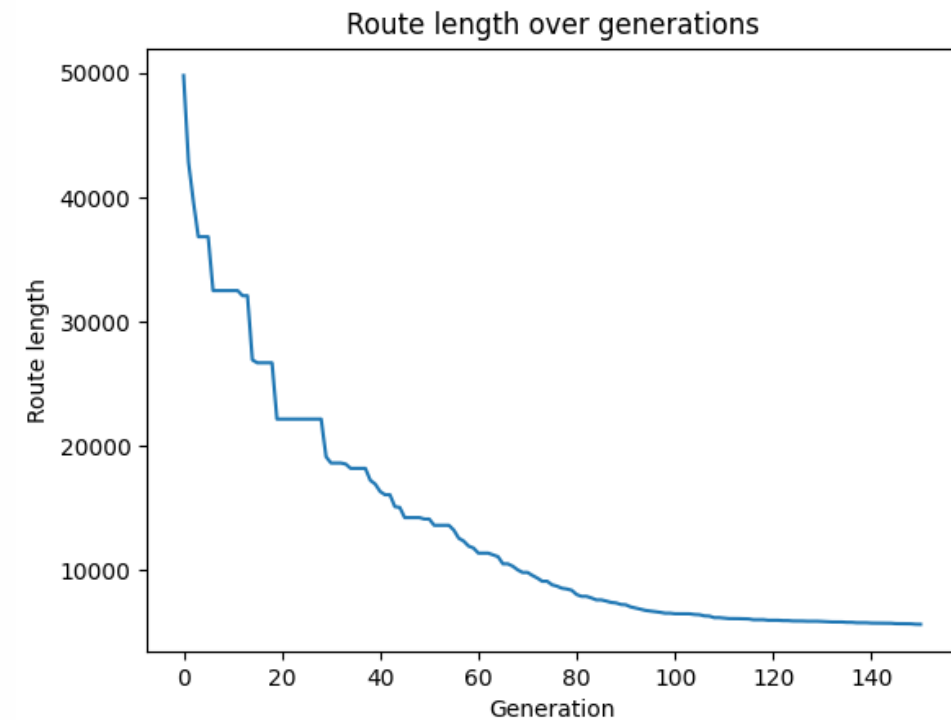
GX – 40 cities



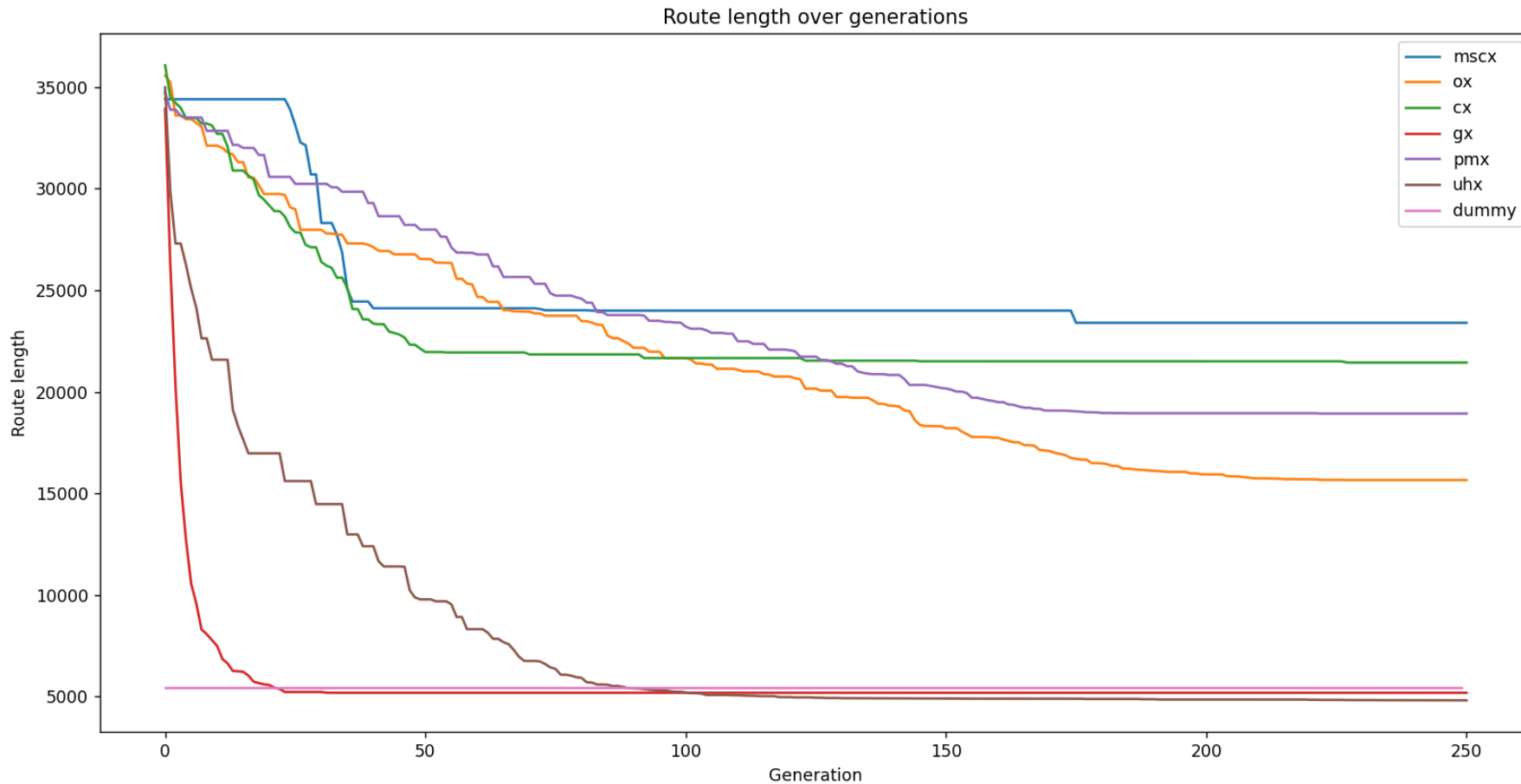
Results - visualization



UHX – 200 cities

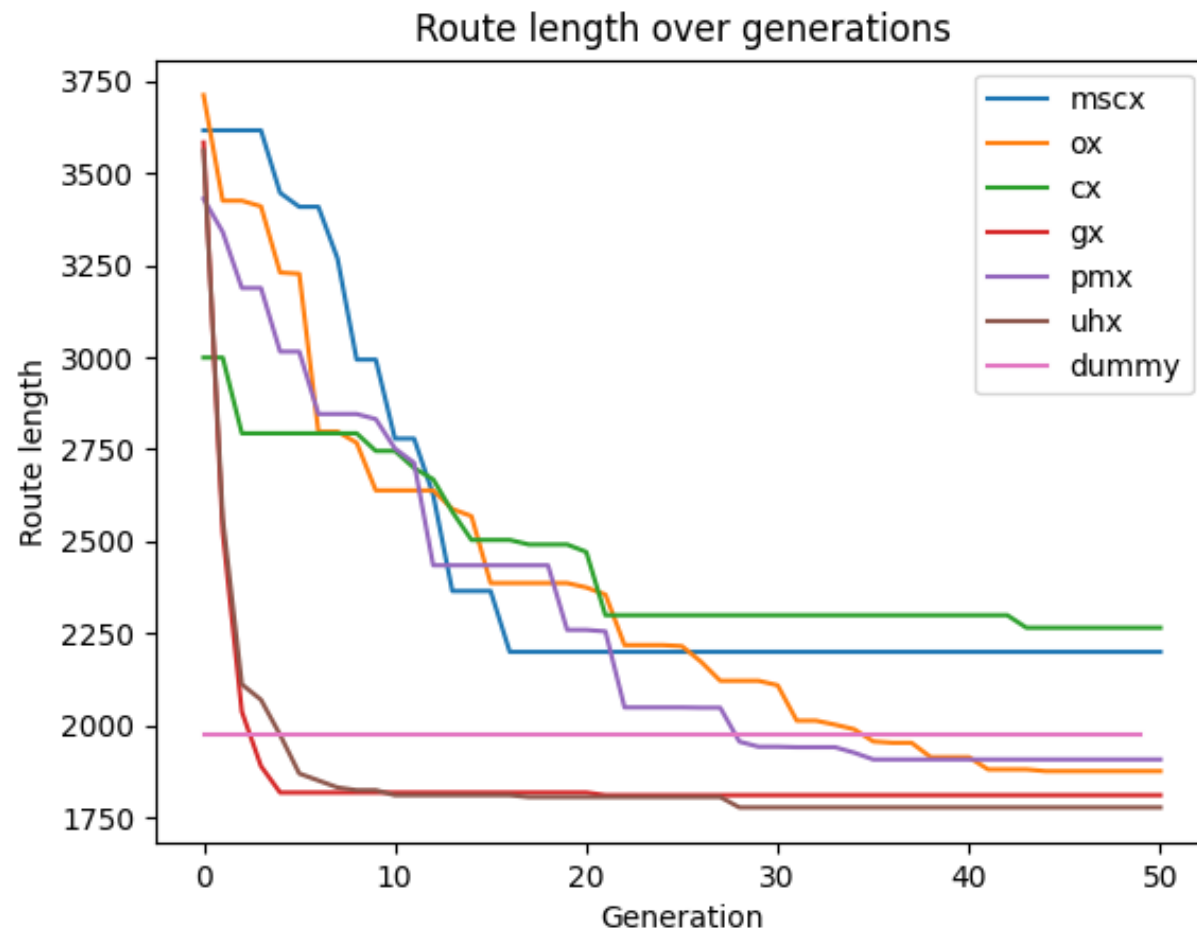


Results – crossover method comparison



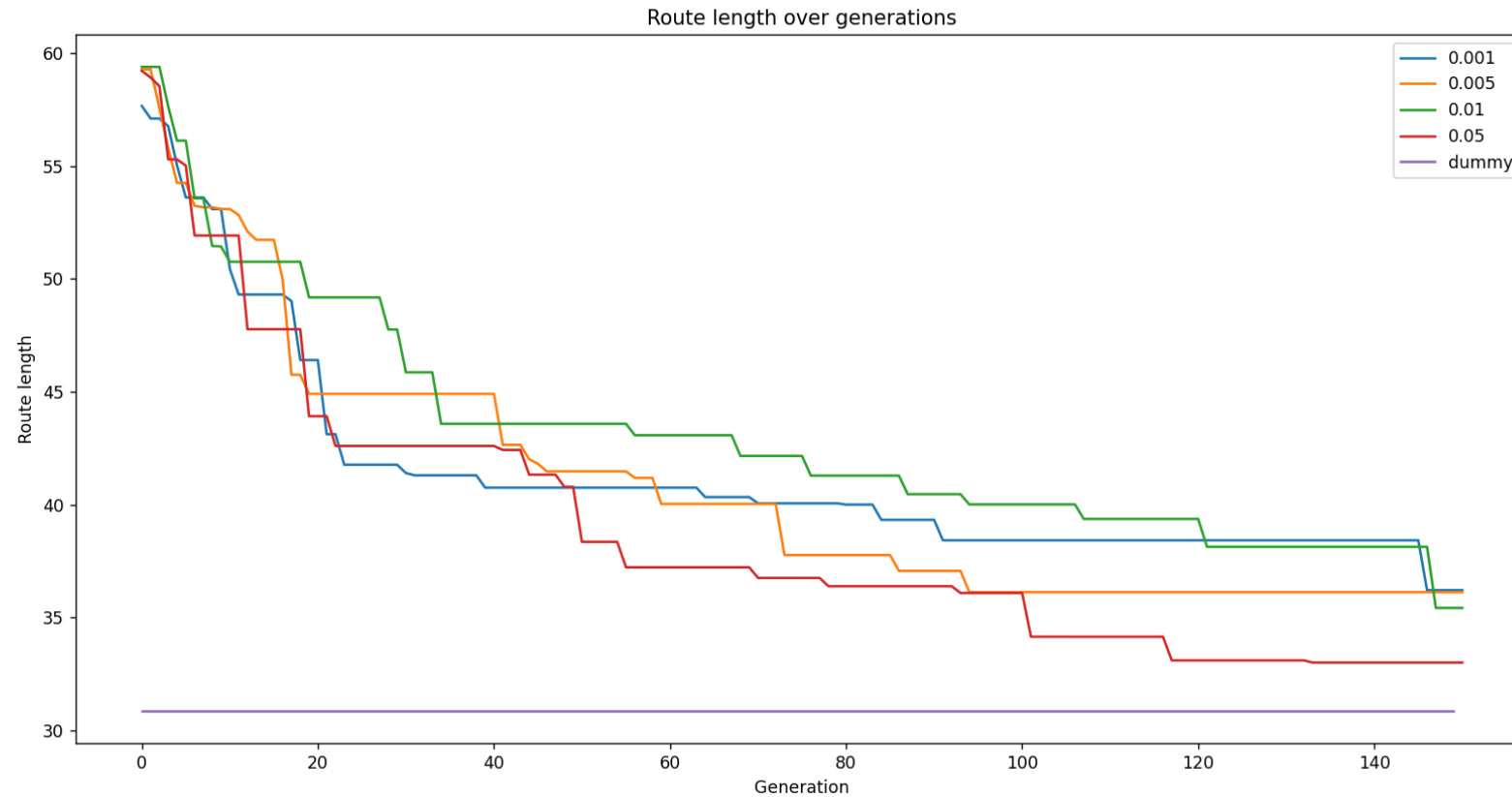
Population – 400
Cities – 150
Tournament method,
Mutation – 0.01

Results – crossover method comparison



Population – 400
Cities – 20
Tournament method,
Mutation – 0.01

Results – mutation rate comparison



Population – 200
Cities – 25
Roulette method,
Crossover - OX