

heuristics

November 18, 2024

```
[2]: import os
import math
import time
```

```
[ ]: path_to_TSP_folder = "heu_e_met_tsp_instances/EUC_2D"
files = [f for f in os.listdir(path_to_TSP_folder) if os.path.isfile(os.path.
↪join(path_to_TSP_folder, f))]
```

```
[4]: class City:
    def __init__(self, index: int, x: float, y:float):
        """x and y are the coordinates of the city"""
        self.index = int(index)
        self.x = x
        self.y = y

    def distance_to(self, d):
        return math.sqrt((self.x - d.x)**2 + (self.y - d.y) ** 2)

    def __str__(self):
        return f"{self.index}, {self.x}, {self.y}"
```

1 Heurística Construtiva

Dada uma instância do problema TSP, a heurística implementada procura sempre pelo vizinho mais próximo da cidade atual.

```
[13]: def constructive_heuristic(instance:list[City]):
    start = time.time()
    curr = instance[1]
    total_dist = 0
    visited = [False for _ in range(len(instance))]

    visited[0] = True
    visited[curr.index] = True
    start = time.time()
    path = [curr]
    while False in visited:
```

```

next_city = None
min_dist = math.inf

for inst in instance[1:]:
    if not visited[inst.index]:

        d = curr.distance_to(inst)

        if d < min_dist:
            min_dist = d
            next_city = inst

curr = next_city

total_dist += round(min_dist)
visited[curr.index] = True
path.append(curr)

total_time = time.time() - start
path.append(instance[1])

return path, total_dist + curr.distance_to(instance[1]), total_time

```

```

[14]: TSP_instance = [None]
NUMBER_OF_EXECUTIONS = 30
instance_name = ""
for f in files:
    with open(os.path.join(path_to_TSP_folder, f), "r") as f:
        instance_name = f.readline().split(":")[1].strip()

        for line in f.readlines()[5:]:
            if(line.strip() == "EOF"):
                break

            values = [float(v.strip()) for v in line.split(" ") if v != "" and
↪ v!="\n"]# we will have [city number, x, y]

            if len(values) < 3:
                print("Error reading TSP instance")

            TSP_instance.append(City(*values))
print(f"Current Instance: {instance_name.strip()}")
print(f"Number of Cities: {len(TSP_instance) - 1}")
t = 0
cost = 0.0

```

```

for _ in range(NUMBER_OF_EXECUTIONS):
    result, c , t1 = constructive_heuristic(TSP_instance)
    cost += c
    t += t1

print(f"Cost: {cost / NUMBER_OF_EXECUTIONS:.02f}\nTime: {t / \
NUMBER_OF_EXECUTIONS * 1000:.4f} ms\nPath:" + ", ".join(str(c.index) for c \
in result))
print("=====")
TSP_instance.clear()
TSP_instance.append(None)

```

Current Instance: pr124

Number of Cities: 124

Cost: 69296.95

Time: 2.0490 ms

Path:1, 8, 2, 3, 4, 6, 32, 31, 30, 34, 33, 59, 61, 60, 62, 66, 65, 64, 63, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 92, 93, 94, 95, 96, 97, 98, 99, 100, 124, 123, 122, 121, 120, 119, 118, 117, 116, 115, 82, 84, 81, 83, 67, 58, 57, 56, 55, 37, 38, 24, 25, 26, 39, 23, 22, 40, 21, 20, 19, 18, 45, 44, 43, 42, 41, 54, 52, 53, 46, 47, 48, 49, 50, 51, 15, 14, 11, 12, 13, 10, 9, 16, 17, 88, 89, 103, 114, 113, 112, 111, 110, 109, 108, 107, 106, 105, 104, 102, 90, 86, 87, 85, 91, 101, 36, 35, 29, 28, 27, 7, 5, 1

=====

Current Instance: kroA150

Number of Cities: 150

Cost: 33611.74

Time: 3.1979 ms

Path:1, 130, 92, 8, 42, 122, 80, 31, 89, 133, 138, 148, 142, 105, 67, 108, 58, 28, 93, 131, 47, 109, 91, 98, 23, 45, 32, 11, 15, 17, 141, 59, 74, 21, 72, 113, 10, 84, 36, 38, 24, 18, 137, 79, 106, 90, 49, 6, 63, 75, 19, 53, 134, 88, 16, 22, 94, 70, 66, 65, 4, 97, 143, 56, 139, 119, 118, 124, 26, 129, 104, 102, 111, 99, 127, 60, 62, 150, 86, 27, 12, 20, 57, 7, 9, 117, 83, 55, 149, 34, 135, 140, 145, 87, 125, 51, 61, 25, 81, 69, 73, 50, 44, 114, 144, 64, 40, 54, 2, 116, 82, 126, 95, 13, 33, 146, 103, 76, 37, 5, 78, 52, 96, 39, 101, 121, 30, 107, 112, 132, 29, 46, 3, 136, 43, 123, 115, 120, 128, 41, 71, 100, 48, 14, 85, 68, 147, 35, 77, 110, 1

=====

Current Instance: kroA100

Number of Cities: 100

Cost: 26853.64

Time: 1.3272 ms

Path:1, 63, 6, 49, 90, 10, 84, 72, 21, 74, 59, 17, 15, 11, 32, 91, 98, 23, 45, 47, 93, 28, 67, 58, 61, 25, 81, 69, 73, 50, 44, 2, 54, 40, 64, 68, 85, 39, 30, 96, 78, 52, 5, 37, 33, 76, 13, 95, 82, 48, 100, 71, 41, 14, 3, 46, 29, 34, 83, 55, 12, 27, 86, 35, 20, 57, 7, 9, 87, 51, 77, 60, 62, 43, 92, 8, 42, 89, 31, 80,

56, 97, 75, 19, 53, 79, 18, 24, 38, 36, 99, 94, 22, 16, 88, 70, 66, 65, 4, 26, 1

=====

Current Instance: rat195

Number of Cities: 195

Cost: 2752.97

Time: 4.8400 ms

Path:1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 25, 24, 23, 22, 21, 20, 19, 18,
17, 16, 15, 14, 27, 28, 29, 30, 31, 32, 33, 46, 47, 48, 49, 50, 51, 52, 39, 38,
37, 36, 35, 34, 45, 44, 43, 42, 41, 40, 53, 54, 55, 56, 57, 58, 71, 72, 73, 74,
75, 76, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80, 79, 66, 67, 68, 69, 70, 59, 60,
61, 62, 63, 64, 65, 78, 77, 90, 91, 104, 103, 102, 101, 100, 99, 98, 97, 96, 95,
94, 93, 92, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 127, 126, 125,
124, 123, 122, 121, 120, 119, 118, 131, 132, 133, 134, 147, 148, 149, 150, 151,
152, 153, 166, 165, 164, 163, 162, 161, 160, 159, 172, 171, 170, 157, 158, 146,
145, 144, 135, 136, 137, 138, 139, 140, 141, 154, 155, 156, 143, 142, 129, 128,
130, 117, 116, 115, 168, 167, 180, 181, 182, 195, 194, 193, 192, 191, 190, 189,
188, 187, 186, 185, 184, 183, 173, 174, 175, 176, 177, 178, 179, 169, 26, 1

=====

Current Instance: kroD100

Number of Cities: 100

Cost: 26947.08

Time: 1.2494 ms

Path:1, 50, 34, 81, 38, 66, 8, 52, 46, 61, 74, 7, 75, 67, 36, 29, 58, 22, 42,
23, 11, 90, 17, 94, 32, 97, 98, 49, 70, 89, 27, 24, 88, 79, 13, 41, 84, 15, 63,
54, 91, 77, 43, 71, 4, 44, 93, 60, 53, 5, 3, 83, 40, 6, 59, 85, 18, 25, 20, 9,
10, 26, 87, 55, 92, 19, 37, 51, 100, 2, 48, 30, 35, 62, 64, 16, 96, 86, 65, 14,
68, 33, 45, 99, 31, 78, 80, 76, 72, 57, 69, 73, 39, 82, 47, 21, 56, 95, 28, 12,
1

=====

Current Instance: pr152

Number of Cities: 152

Cost: 85699.32

Time: 2.8885 ms

Path:1, 35, 36, 34, 16, 2, 15, 32, 33, 37, 3, 31, 30, 29, 14, 4, 13, 27, 28, 38,
5, 26, 25, 24, 12, 6, 11, 22, 23, 39, 7, 20, 21, 19, 10, 8, 9, 17, 18, 40, 41,
60, 61, 62, 63, 64, 59, 58, 42, 83, 105, 106, 107, 86, 84, 85, 108, 109, 110,
104, 111, 112, 103, 102, 101, 88, 81, 67, 68, 56, 55, 44, 66, 65, 57, 43, 82,
87, 89, 100, 113, 114, 99, 98, 97, 90, 79, 71, 72, 53, 52, 46, 70, 69, 54, 45,
80, 91, 96, 115, 116, 95, 94, 93, 92, 77, 74, 76, 50, 49, 48, 75, 73, 51, 47,
78, 123, 128, 127, 151, 150, 152, 126, 125, 124, 122, 129, 130, 149, 148, 147,
131, 132, 121, 120, 133, 134, 146, 145, 144, 135, 136, 119, 118, 137, 138, 143,
142, 141, 139, 140, 117, 1

=====

Current Instance: kroB150

Number of Cities: 150

Cost: 32825.33

Time: 2.9071 ms

Path:1, 53, 85, 27, 15, 13, 79, 110, 64, 20, 55, 42, 67, 31, 47, 6, 149, 54,

134, 75, 22, 112, 8, 106, 17, 25, 90, 34, 145, 109, 98, 148, 88, 28, 39, 38, 71,
124, 72, 83, 62, 138, 113, 108, 114, 126, 101, 56, 119, 5, 43, 86, 133, 50, 95,
94, 123, 91, 70, 111, 121, 76, 131, 139, 21, 122, 89, 41, 59, 3, 73, 118, 69,
74, 57, 36, 100, 33, 45, 81, 97, 144, 136, 10, 92, 99, 141, 19, 105, 143, 93,
49, 18, 29, 37, 120, 16, 135, 146, 127, 51, 63, 44, 66, 103, 128, 84, 11, 52,
150, 96, 87, 48, 14, 4, 116, 60, 140, 115, 77, 80, 147, 65, 130, 107, 104, 2,
35, 68, 30, 23, 102, 129, 58, 40, 12, 46, 125, 142, 132, 32, 117, 24, 61, 26,
78, 9, 82, 7, 137, 1

=====
Current Instance: pr136

Number of Cities: 136

Cost: 120769.17

Time: 2.2848 ms

Path:1, 17, 19, 31, 29, 30, 5, 6, 7, 8, 2, 16, 20, 32, 27, 28, 38, 51, 53, 65,
63, 64, 39, 40, 41, 42, 37, 50, 54, 66, 61, 62, 72, 84, 86, 99, 97, 98, 73, 74,
75, 76, 71, 83, 87, 100, 95, 96, 106, 118, 120, 136, 131, 132, 107, 108, 109,
110, 105, 117, 121, 135, 129, 130, 119, 85, 52, 18, 15, 9, 10, 3, 14, 21, 33,
25, 26, 43, 44, 36, 48, 55, 67, 59, 60, 49, 77, 78, 70, 82, 89, 101, 93, 94, 88,
111, 112, 104, 116, 123, 134, 127, 128, 122, 113, 114, 103, 115, 124, 133, 125,
126, 92, 91, 102, 90, 81, 69, 80, 79, 58, 57, 68, 56, 47, 35, 46, 45, 24, 23,
34, 22, 13, 4, 12, 11, 1

=====
Current Instance: kroE100

Number of Cities: 100

Cost: 27585.40

Time: 1.2652 ms

Path:1, 74, 21, 7, 76, 12, 32, 58, 63, 88, 35, 40, 99, 45, 54, 25, 97, 80, 57,
10, 60, 50, 49, 56, 15, 20, 23, 64, 95, 36, 59, 98, 51, 69, 47, 83, 73, 16, 61,
71, 89, 81, 79, 26, 46, 3, 14, 52, 44, 72, 68, 38, 33, 48, 90, 42, 5, 8, 65, 31,
66, 30, 93, 91, 55, 6, 34, 37, 85, 96, 77, 70, 4, 2, 11, 82, 92, 27, 67, 41, 75,
87, 9, 13, 39, 43, 86, 19, 94, 18, 24, 29, 100, 78, 53, 22, 17, 84, 62, 28, 1

=====
Current Instance: pr107

Number of Cities: 107

Cost: 46680.00

Time: 1.3653 ms

Path:1, 3, 4, 6, 5, 2, 7, 9, 10, 11, 8, 12, 13, 15, 16, 18, 17, 14, 20, 23, 24,
21, 19, 22, 25, 27, 28, 30, 29, 26, 32, 35, 36, 33, 31, 34, 37, 39, 40, 42, 41,
38, 44, 47, 48, 45, 43, 46, 49, 51, 52, 54, 53, 50, 55, 106, 104, 107, 105, 103,
100, 102, 101, 56, 99, 96, 57, 94, 97, 98, 95, 93, 90, 92, 91, 58, 89, 86, 59,
84, 87, 88, 85, 83, 80, 82, 81, 60, 79, 76, 61, 74, 77, 78, 75, 72, 69, 71, 73,
62, 70, 66, 63, 64, 67, 68, 65, 1

=====
Current Instance: pr76

Number of Cities: 76

Cost: 153462.30

Time: 0.7134 ms

Path:1, 2, 23, 22, 21, 25, 24, 46, 45, 44, 48, 47, 69, 68, 67, 50, 49, 52, 53,

54, 42, 43, 28, 29, 30, 31, 19, 20, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,
17, 18, 37, 36, 35, 34, 40, 41, 60, 59, 58, 57, 63, 64, 62, 61, 55, 56, 51, 66,
65, 71, 72, 73, 39, 38, 32, 33, 27, 26, 4, 3, 75, 76, 74, 70, 1

=====

Current Instance: kroC100

Number of Cities: 100

Cost: 26327.28

Time: 1.2304 ms

Path:1, 53, 85, 27, 15, 13, 79, 64, 20, 55, 42, 67, 31, 47, 6, 54, 75, 22, 8,
17, 25, 90, 34, 58, 98, 88, 28, 39, 38, 71, 56, 5, 43, 86, 50, 72, 83, 62, 2,
35, 68, 30, 89, 41, 59, 3, 73, 69, 74, 57, 36, 100, 33, 45, 81, 97, 10, 92, 99,
19, 14, 4, 60, 93, 49, 18, 29, 37, 61, 26, 78, 9, 82, 7, 32, 24, 46, 12, 40, 65,
80, 77, 23, 70, 76, 91, 94, 95, 21, 66, 44, 63, 16, 51, 48, 84, 11, 52, 96, 87,
1

=====

Current Instance: kroB100

Number of Cities: 100

Cost: 29158.46

Time: 1.5881 ms

Path:1, 95, 98, 12, 71, 27, 61, 35, 94, 57, 34, 7, 84, 58, 52, 54, 43, 89, 87,
60, 74, 66, 4, 83, 6, 15, 33, 82, 64, 14, 42, 2, 13, 78, 17, 45, 36, 96, 92, 19,
44, 41, 18, 24, 77, 16, 50, 55, 22, 23, 88, 37, 72, 65, 79, 81, 47, 56, 100, 26,
69, 62, 5, 67, 40, 39, 70, 53, 73, 85, 93, 11, 3, 28, 91, 97, 99, 8, 29, 32, 59,
76, 90, 21, 86, 49, 30, 75, 80, 20, 38, 46, 25, 9, 68, 10, 63, 31, 48, 51, 1

=====

Current Instance: lin105

Number of Cities: 105

Cost: 20356.39

Time: 1.4284 ms

Path:1, 2, 6, 7, 10, 11, 15, 103, 21, 22, 29, 30, 31, 32, 28, 23, 20, 19, 24,
27, 26, 25, 18, 16, 17, 9, 8, 3, 12, 33, 36, 37, 42, 43, 46, 52, 53, 58, 57, 54,
51, 47, 44, 41, 104, 40, 45, 48, 50, 55, 56, 59, 105, 62, 63, 70, 74, 75, 81,
69, 73, 76, 80, 79, 77, 72, 68, 67, 71, 78, 82, 83, 84, 85, 86, 89, 90, 99, 98,
93, 92, 91, 96, 97, 101, 102, 64, 49, 39, 38, 35, 34, 14, 13, 5, 4, 60, 61, 65,
66, 87, 88, 94, 95, 100, 1

=====

Current Instance: kroB200

Number of Cities: 200

Cost: 36976.32

Time: 5.6583 ms

Path:1, 95, 98, 174, 12, 161, 71, 27, 176, 180, 94, 57, 34, 169, 58, 84, 7, 52,
116, 163, 54, 154, 191, 177, 143, 171, 88, 22, 23, 104, 144, 193, 160, 153, 24,
18, 105, 77, 103, 183, 140, 106, 159, 50, 164, 185, 118, 14, 125, 120, 42, 109,
2, 155, 13, 126, 187, 63, 31, 48, 195, 156, 121, 82, 64, 33, 147, 15, 112, 128,
51, 110, 78, 17, 192, 41, 148, 102, 200, 92, 151, 19, 137, 96, 119, 36, 45, 162,
135, 130, 44, 16, 55, 139, 173, 115, 37, 72, 184, 141, 65, 124, 127, 188, 79,
113, 179, 81, 47, 101, 150, 69, 26, 100, 56, 62, 132, 5, 197, 67, 40, 117, 190,
189, 111, 68, 10, 123, 142, 85, 122, 73, 53, 170, 149, 70, 198, 39, 194, 75, 30,

181, 134, 49, 86, 138, 166, 108, 152, 38, 20, 80, 146, 46, 25, 9, 90, 21, 3,
158, 11, 93, 28, 129, 91, 97, 99, 8, 29, 136, 59, 167, 175, 32, 76, 107, 35, 61,
172, 157, 131, 199, 178, 74, 165, 60, 186, 196, 43, 89, 87, 114, 168, 133, 66,
145, 4, 83, 182, 6, 1

=====

Current Instance: berlin52

Number of Cities: 52

Cost: 8980.11

Time: 0.3622 ms

Path:1, 22, 49, 32, 36, 35, 34, 39, 40, 38, 37, 48, 24, 5, 15, 6, 4, 25, 46, 44,
16, 50, 20, 23, 31, 18, 3, 19, 45, 41, 8, 10, 9, 43, 33, 51, 12, 28, 27, 26, 47,
13, 14, 52, 11, 29, 30, 21, 17, 42, 7, 2, 1

=====

Current Instance: pr144

Number of Cities: 144

Cost: 61651.80

Time: 2.7732 ms

Path:1, 2, 3, 4, 5, 6, 28, 29, 30, 27, 26, 35, 36, 25, 24, 23, 22, 37, 38, 39,
40, 21, 18, 17, 41, 42, 16, 15, 20, 19, 8, 7, 9, 10, 11, 12, 13, 14, 43, 44, 45,
71, 72, 70, 69, 68, 67, 66, 65, 64, 63, 62, 61, 60, 59, 48, 47, 46, 58, 57, 56,
55, 54, 53, 52, 51, 50, 49, 83, 84, 82, 81, 80, 79, 85, 86, 110, 109, 108, 107,
106, 105, 104, 88, 87, 103, 102, 101, 100, 99, 98, 97, 96, 95, 94, 93, 90, 89,
78, 77, 76, 75, 74, 73, 91, 92, 116, 117, 118, 119, 120, 121, 122, 123, 124,
125, 126, 127, 128, 129, 130, 134, 133, 132, 131, 115, 135, 136, 137, 138, 139,
140, 141, 142, 143, 144, 111, 112, 113, 114, 31, 32, 33, 34, 1

=====

Current Instance: rat99

Number of Cities: 99

Cost: 1557.80

Time: 1.2894 ms

Path:1, 2, 3, 12, 11, 10, 20, 19, 28, 37, 29, 30, 31, 32, 41, 42, 43, 34, 33,
44, 36, 35, 26, 25, 24, 23, 15, 16, 17, 18, 9, 8, 7, 6, 5, 14, 4, 13, 22, 21,
38, 39, 48, 40, 50, 51, 52, 53, 54, 45, 63, 62, 61, 60, 49, 58, 59, 67, 68, 78,
77, 76, 85, 84, 83, 82, 91, 92, 93, 94, 95, 86, 87, 88, 79, 80, 71, 70, 69, 72,
81, 90, 89, 99, 98, 97, 96, 75, 74, 66, 65, 56, 57, 47, 46, 55, 64, 73, 27, 1

=====

Current Instance: kroA200

Number of Cities: 200

Cost: 35794.03

Time: 5.1084 ms

Path:1, 53, 115, 117, 111, 132, 85, 145, 191, 198, 27, 123, 15, 13, 79, 160,
162, 64, 20, 55, 42, 135, 186, 127, 112, 120, 47, 31, 67, 177, 65, 80, 161, 125,
181, 2, 35, 169, 68, 30, 89, 41, 59, 3, 73, 189, 69, 142, 131, 180, 156, 100,
33, 45, 197, 81, 97, 104, 165, 166, 96, 126, 87, 52, 11, 84, 48, 170, 122, 116,
188, 44, 63, 16, 118, 124, 138, 9, 78, 82, 199, 26, 136, 61, 32, 24, 159, 174,
121, 46, 172, 29, 110, 18, 49, 190, 149, 106, 93, 163, 4, 101, 60, 128, 193,
158, 77, 151, 187, 6, 109, 107, 157, 54, 75, 183, 155, 8, 22, 134, 129, 146,
103, 143, 90, 34, 25, 17, 114, 98, 88, 148, 28, 39, 38, 71, 130, 72, 83, 62,

185, 168, 173, 23, 144, 70, 76, 91, 150, 94, 95, 50, 139, 86, 5, 105, 43, 137,
178, 152, 56, 196, 200, 171, 58, 141, 133, 176, 113, 195, 182, 102, 21, 140,
164, 154, 167, 108, 192, 14, 36, 57, 74, 175, 10, 92, 99, 19, 119, 66, 153, 179,
51, 194, 37, 184, 12, 147, 40, 7, 1

=====

Current Instance: st70

Number of Cities: 70

Cost: 801.00

Time: 0.6154 ms

Path:1, 36, 23, 47, 16, 37, 58, 50, 10, 52, 60, 12, 21, 34, 33, 54, 62, 48, 67,
56, 65, 51, 11, 64, 5, 53, 66, 63, 22, 59, 38, 69, 31, 13, 29, 70, 35, 57, 15,
24, 2, 7, 32, 3, 8, 28, 26, 49, 55, 19, 4, 18, 42, 6, 41, 43, 17, 9, 40, 61, 39,
45, 25, 46, 27, 68, 44, 30, 20, 14, 1

=====