CS 312, Lab 4 - Report

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Abstract:

Using any algorithm find the tour with least cost tour between cities forming Hamiltonian cycle
in given time limit of 300 sec. It encloses the concept of Travelling Salesman Problem. There is no known
algorithm to solve the TSP that is both optimal and efficient

Algorithms used In the code:

Nearest Neighbor:

The Nearest-Neighbor Algorithm begins at any vertex and follows the edge of least weight from that
vertex. At every subsequent vertex, it follows the edge of least weight that leads to a city not yet visited,
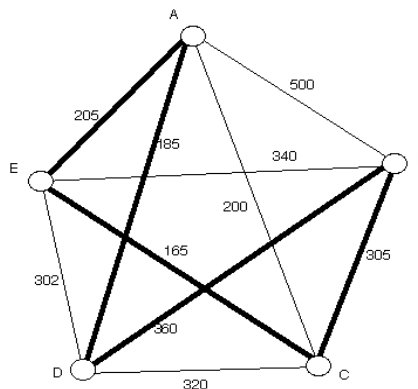until it returns to the starting point.

Fig: Nearest Neighbor example

Algorithm:

```
function nearest neighbor (distance matrix, starting point):
    path = [starting point]
    cost = 0
    mask <-store visited
    for i in range(number of nodes):
        path<-add nearest city to current city(path(i-1)) which is unvisited
        visited<-path[i]
    return path, cost
```

Repetitive Nearest-Neighbor Algorithm

The Repetitive Nearest-Neighbor Algorithm applies the nearest-neighbor algorithm repeatedly, using each of the vertices as a starting point. It selects the starting point that produced the shortest circuit.
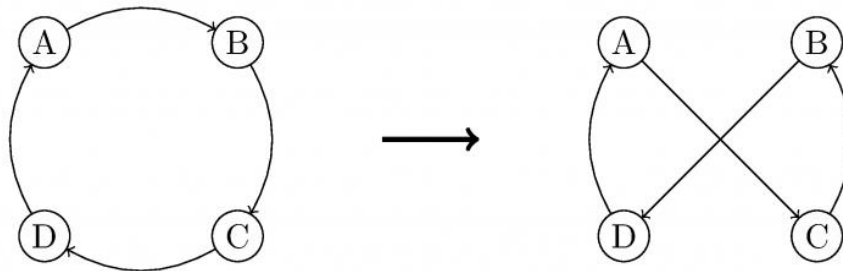
Algorithm:

```
bestcost = infinite
for city in range(number of cities):
        path, cost = nearest neighbor (distance matrix, city)
        if cost < bestcost:
            bestcost = cost
            route = path
```

2-opt algorithm

2-opt algorithm is one of the most basic and widely used heuristic for obtaining approximative solution of TSP problem. 2-opt starts with random initial tour and it improves the tour incrementally by exchanging 2 edges in the tour with two other edges.

$$\Delta ij = c(u1,u2) + c(v1,v2) - (c(u1,v1) + .c(u2,v2))$$

Algorithm:

improved = True

```
while improved:
        for i in range(1, len(route) - 2):
            for j in range(i + 1, len(route)):
                if j - i == 1: continue
                if check_cost_change(cost_mat, best[i - 1], best[i], best[j - 1], best[j]) < 0:
                    best[i:j] = best[j - 1:i - 1:-1]
            route = best
```
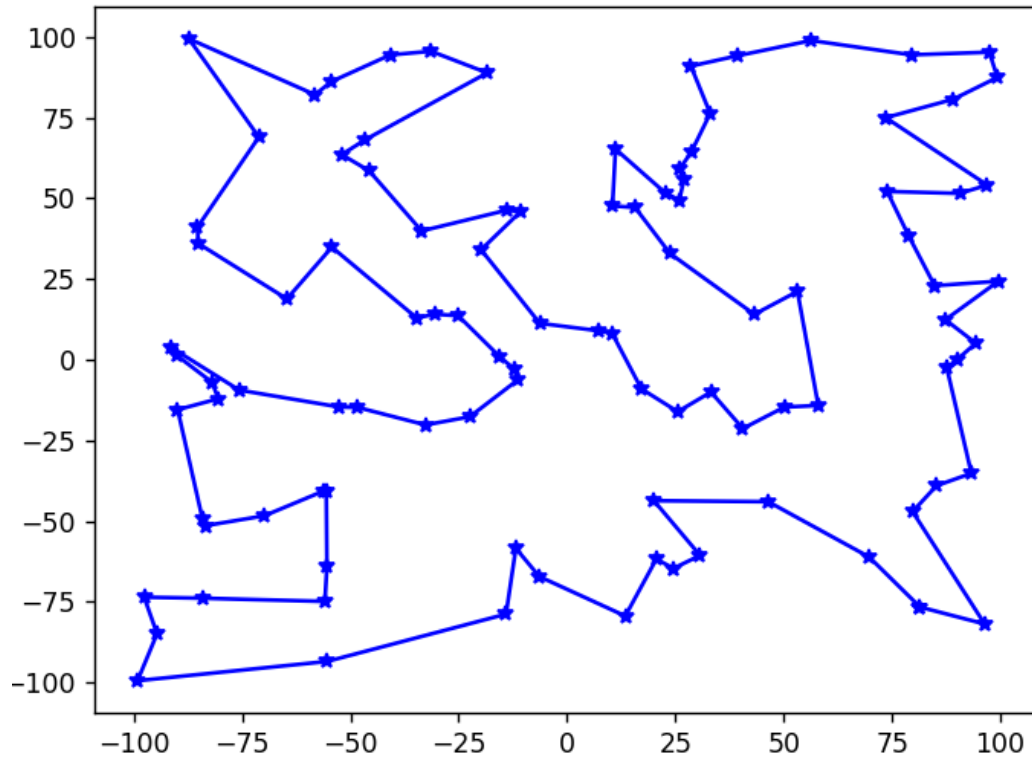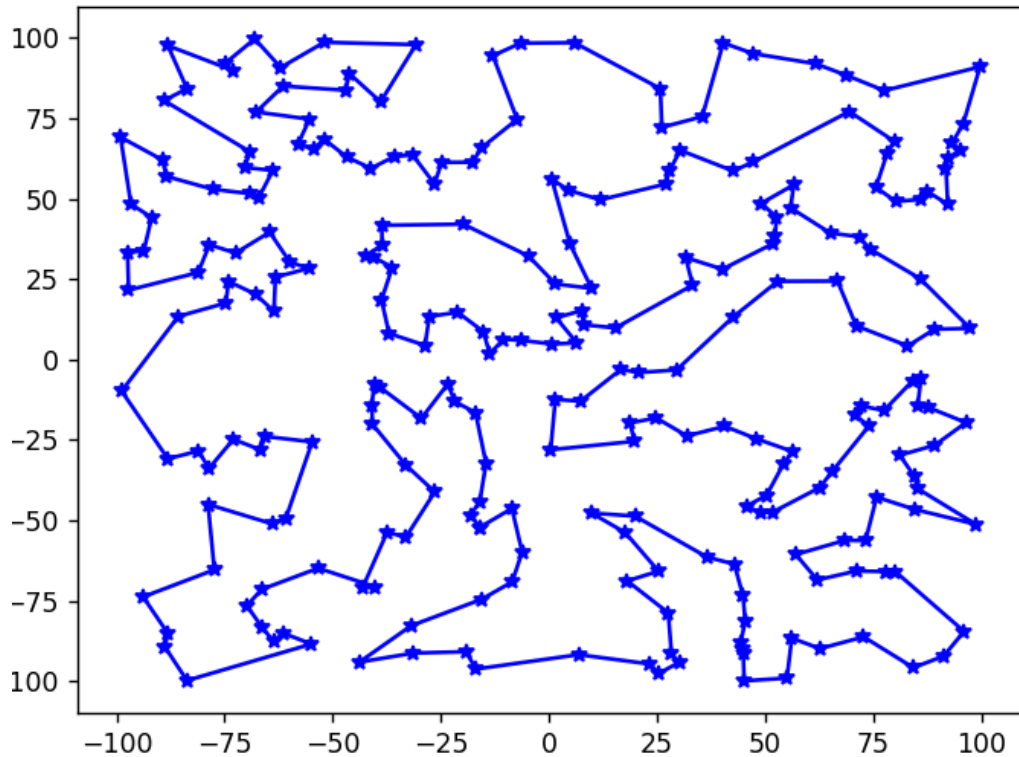
Results / Output:

For euc_100:

best path: [16, 26, 72, 11, 28, 60, 27, 74, 96, 34, 92, 81, 21, 39, 24, 47, 5, 76, 6, 95, 69, 83, 68, 31, 49, 23, 14, 51, 91, 82, 7, 56, 65, 0, 38, 19, 4, 57, 85, 10, 18, 13, 52, 86, 80, 53, 45, 62, 44, 42, 90, 3, 94, 40, 67, 89, 35, 78, 58, 37, 77, 71, 59, 17, 99, 33, 84, 15, 64, 55, 9, 30, 61, 43, 87, 50, 70, 79, 66, 32, 12, 93, 2, 25, 20, 46, 8, 73, 75, 88, 98, 36, 29, 41, 48, 63, 1, 54, 97, 22]

number of elements in route 100

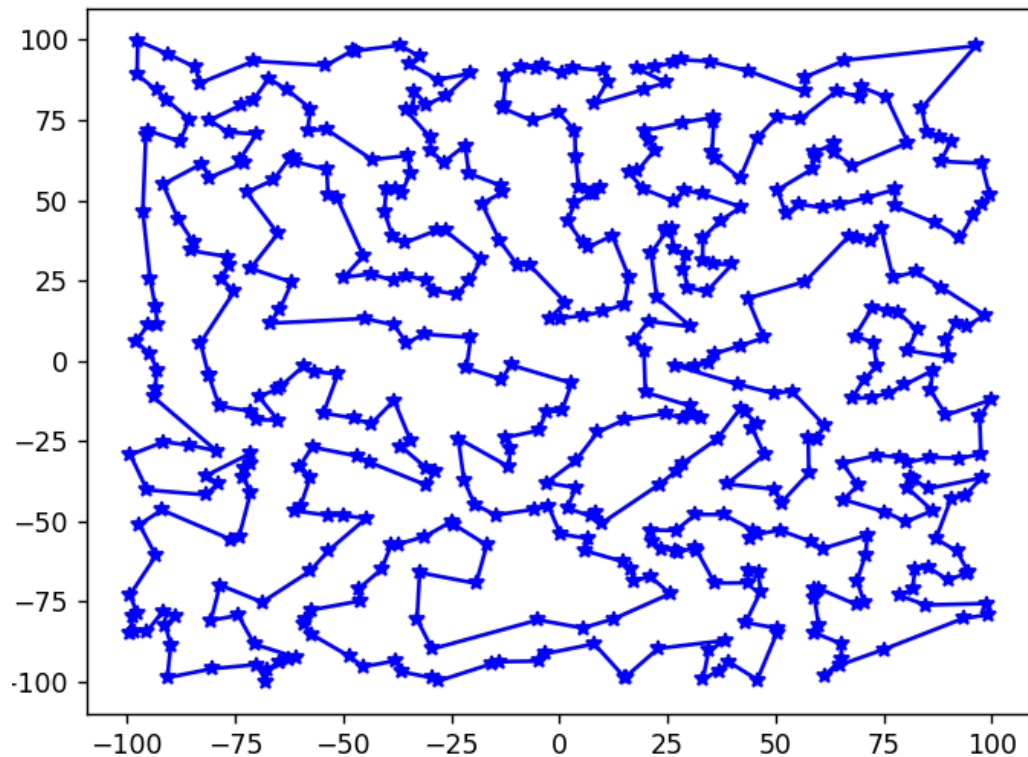**least cost achieved: 1577.0853407829004**

For euc_250:

best path: [52, 169, 21, 167, 0, 2, 67, 157, 144, 90, 143, 219, 64, 204, 80, 11, 193, 117, 83, 176, 220, 185, 56, 229, 203, 212, 102, 235, 125, 111, 22, 127, 124, 233, 38, 95, 40, 84, 45, 162, 148, 210, 146, 24, 172, 218, 13, 161, 25, 180, 39, 188, 136, 50, 130, 65, 35, 216, 234, 249, 110, 227, 214, 46, 200, 23, 177, 207, 78, 47, 246, 242, 187, 116, 49, 98, 209, 48, 94, 237, 154, 14, 239, 138, 62, 107, 150, 131, 213, 221, 17, 171, 182, 29, 61, 15, 196, 190, 163, 114, 34, 82, 181, 87, 165, 6, 189, 147, 12, 121, 44, 96, 51, 76, 66, 158, 194, 202, 226, 140, 245, 134, 54, 160, 7, 178, 241, 119, 72, 81, 37, 91, 137, 31, 85, 191, 43, 108, 156, 149, 3, 173, 106, 243, 36, 236, 240, 224, 68, 73, 93, 215, 129, 206, 145, 205, 109, 27, 244, 228, 170, 75, 155, 152, 112, 70, 28, 9, 74, 42, 33, 225, 211, 174, 128, 247, 97, 232, 217, 8, 135, 186, 103, 55, 1, 153, 120, 122, 60, 123, 100, 199, 197, 164, 89, 88, 99, 201, 92, 101, 184, 41, 248, 77, 168, 53, 105, 222, 198, 151, 183, 30, 179, 159, 104, 4, 69, 19, 58, 118, 5, 141, 192, 20, 175, 238, 139, 142, 26, 16, 166, 223, 195, 71, 113, 208, 10, 115, 126, 133, 57, 231, 132, 18, 63, 79, 230, 32, 59, 86]

length of route 250
least cost achieved: 2514.1813064652597

For euc_500:

Path: [25, 179, 235, 322, 431, 236, 33, 445, 480, 374, 130, 156, 333, 228, 304, 361, 2, 135, 74, 290, 50, 57, 120, 294, 276, 90, 101, 154, 308, 492, 108, 377, 148, 248, 405, 206, 217, 53, 47, 144, 141, 151, 495, 54, 64, 295, 397, 305, 286, 475, 449, 468, 254, 222, 487, 23, 450, 174, 455, 360, 320, 426, 332, 474, 94, 390, 76, 368, 186, 383, 241, 257, 456, 490, 478, 122, 79, 385, 367, 24, 496, 302, 216, 127, 489, 394, 365, 4, 0, 334, 115, 175, 498, 412, 292, 237, 110, 253, 71, 256, 262, 283, 199, 229, 299, 41, 105, 341, 66, 92, 370, 17, 471, 358, 293, 301, 28, 158, 422, 39, 303, 493, 381, 270, 392, 11, 414, 44, 311, 167, 131, 310, 491, 484, 165, 272, 351, 393, 8, 12, 35, 267, 73, 78, 457, 271, 434, 234, 473, 349, 432, 207, 243, 29, 437, 150, 139, 59, 486, 97, 119, 193, 155, 297, 402, 375, 355, 287, 476, 386, 337, 380, 354, 15, 249, 423, 280, 189, 209, 447, 104, 313, 344, 378, 51, 439, 227, 5, 404, 37, 77, 251, 353, 129, 403, 466, 82, 109, 470, 415, 441, 429, 389, 188, 433, 224, 454, 289, 7, 192, 208, 369, 6, 210, 215, 22, 401, 184, 461, 298, 488, 60, 438, 164, 418, 219, 63, 200, 326, 107, 99, 250, 485, 233, 38, 321, 48, 359, 166, 231, 238, 3, 409, 91, 425, 384, 319, 18, 181, 356, 43, 317, 19, 246, 291, 269, 273, 281, 481, 140, 448, 247, 479, 350, 282, 417, 406, 213, 261, 212, 296, 338, 352, 211, 443, 463, 185, 364, 87, 416, 421, 230, 346, 363, 411, 180, 278, 372, 316, 226, 138, 162, 331, 494, 462, 9, 413, 146, 157, 202, 159, 88, 410, 20, 430, 136, 21, 362, 75, 114, 117, 98, 420, 95, 459, 336, 340, 65, 373, 134, 145, 204, 133, 442, 288, 342, 309, 314, 160, 61, 428, 325, 239, 69, 244, 263, 376, 335, 49, 70, 172, 178, 357, 315, 379, 137, 203, 161, 458, 464, 52, 499, 45, 1, 266, 205, 221, 395, 242, 113, 46, 13, 444, 34, 86, 16, 190, 83, 198, 89, 30, 132, 483, 106, 446, 324, 460, 328, 232, 183, 391, 195, 240, 268, 103, 168, 10, 265, 274, 347, 27, 440, 343, 14, 306, 465, 408, 191, 285, 197, 40, 279, 312, 123, 407, 482, 173, 467, 171, 387, 400, 31, 153, 327, 497, 307, 176, 67, 42, 84, 55, 147, 125, 201, 255, 68, 124, 72, 419, 264, 116, 277, 118, 149, 252, 399, 284, 225, 345, 398, 177, 388, 81, 436, 339, 214, 142, 275, 196, 85, 143, 469, 121, 427, 453, 424, 258, 366, 169, 112, 93, 223, 26, 318, 170, 187, 62, 477, 100, 182, 163, 382, 218, 435, 259, 371, 452, 128, 56, 80, 220, 260, 126, 451, 96, 472, 245, 348, 36, 323, 152, 194, 300, 102, 32, 111, 330, 396, 329, 58]

number of elements in route 500

least cost achieved: 3517.302704985185

for Noneuc 100:

[3, 4, 72, 80, 98, 10, 57, 73, 38, 16, 87, 59, 36, 7, 11, 44, 18, 94, 70, 67, 30, 40, 2, 25, 34, 51, 69, 19, 42, 49, 95, 47, 26, 93, 60, 71, 1, 12, 68, 82, 0, 76, 79, 13, 52, 78, 62, 61, 90, 9, 23, 66, 54, 45, 32, 6, 20, 35, 88, 5, 65, 43, 48, 56, 86, 91, 63, 92, 55, 17, 58, 83, 31, 77, 33, 39, 24, 81, 74, 28, 22, 64, 21, 75, 29, 27, 15, 84, 8, 41, 37, 96, 85, 50, 14, 53, 97, 89, 99, 46]

number of elements in route 100
least cost achieved: 5264.384692600998

for noneuc 250:

[194, 237, 138, 219, 202, 248, 232, 206, 17, 174, 89, 173, 164, 81, 154, 31, 147, 79, 246, 162, 9, 62, 197, 86, 127, 124, 47, 70, 165, 28, 90, 2, 107, 55, 204, 140, 136, 82, 97, 199, 144, 187, 212, 93, 161, 160, 207, 50, 225, 226, 177, 61, 243, 123, 167, 109, 34, 115, 20, 184, 13, 229, 10, 18, 22, 245, 49, 249, 209, 168, 102, 74, 150, 4, 56, 239, 186, 236, 104, 234, 15, 103, 195, 247, 33, 39, 240, 76, 85, 43, 21, 208, 166, 84, 52, 223, 92, 142, 32, 148, 118, 23, 210, 125, 27, 228, 8, 183, 38, 69, 60, 213, 227, 105, 131, 149, 25, 193, 242, 46, 224, 163, 12, 67, 120, 233, 44, 146, 141, 41, 65, 75, 111, 143, 119, 1, 101, 26, 80, 110, 205, 222, 241, 5, 30, 200, 216, 198, 230, 24, 108, 83, 48, 129, 40, 14, 113, 121, 244, 156, 78, 231, 112, 54, 53, 192, 114, 181, 176, 188, 203, 7, 152, 95, 0, 42, 126, 99, 178, 36, 35, 19, 172, 221, 153, 66, 137, 215, 235, 116, 3, 58, 128, 88, 132, 175, 133, 134, 190, 145, 170, 196, 117, 169, 180, 100, 72, 91, 151, 122, 37, 94, 155, 64, 139, 214, 171, 130, 59, 45, 218, 6, 77, 11, 211, 106, 135, 220, 185, 57, 157, 63, 29, 87, 98, 189, 217, 16, 159, 191, 201, 73, 158, 71, 182, 51, 238, 68, 179, 96]

number of elements in route 250
least cost achieved: 12802.590568541596

for noneuc 500:
[449, 293, 56, 34, 136, 140, 218, 200, 273, 104, 19, 193, 294, 97, 232, 416, 448, 9, 471, 60, 402, 204, 23, 274, 122, 29, 92, 233, 421, 146, 264, 283, 8, 353, 12, 137, 189, 336, 133, 216, 498, 470, 143, 420, 170, 115, 259, 271, 361, 149, 258, 368, 329, 334, 150, 165, 422, 314, 369, 43, 151, 166, 107, 381, 424, 96, 209, 99, 120, 28, 61, 191, 203, 475, 54, 152, 265, 464, 79, 364, 487, 196, 38, 158, 425, 398, 367, 210, 332, 192, 322, 454, 127, 482, 343, 221, 164, 392, 491, 426, 37, 478, 289, 374, 359, 134, 494, 393, 184, 452, 456, 246, 17, 324, 375, 68, 47, 205, 295, 108, 358, 75, 287, 493, 247, 319, 310, 138, 253, 268, 399, 355, 440, 168, 352, 320, 423, 396, 342, 123, 111, 77, 100, 83, 208, 132, 238, 489, 356, 327, 330, 163, 231, 434, 460, 455, 442, 5, 176, 340, 66, 198, 36, 30, 305, 190, 177, 98, 378, 291, 84, 261, 173, 433, 67, 245, 46, 25, 171, 404, 290, 357, 74, 63, 445, 249, 285, 57, 350, 297, 201, 465, 155, 492, 248, 260, 153, 90, 288, 306, 344, 117, 59, 195, 142, 40, 139, 135, 459, 121, 72, 377, 436, 371, 55, 147, 215, 345, 451, 217, 348, 110, 70, 26, 277, 251, 450, 118, 376, 243, 379, 154, 58, 441, 279, 467, 16, 435, 15, 11, 229, 447, 354, 299, 308, 397, 131, 157, 53, 89, 105, 182, 113, 437, 103, 370, 386, 124, 7, 311, 388, 128, 194, 206, 236, 230, 380, 403, 39, 22, 335, 417, 227, 389, 237, 185, 0, 328, 469, 172, 167, 468, 458, 333, 383, 24, 207, 472, 269, 224, 180, 31, 387, 199, 234, 226, 86, 73, 148, 281, 490, 32, 317, 276, 480, 479, 101, 390, 187, 304, 499, 179, 69, 114, 240, 211, 481, 64, 174, 495, 406, 384, 309, 405, 14, 363, 347, 443, 411, 188, 254, 235, 315, 366, 497, 486, 313, 220, 391, 410, 339, 461, 13, 278, 321, 267, 239, 76, 250, 270, 485, 341, 125, 318, 175, 292, 323, 141, 302, 1, 462, 126, 87, 466, 109, 414, 484, 80, 382, 349, 49, 129, 21, 496, 183, 2, 431, 263, 275, 88, 33, 256, 325, 337, 373, 228, 418, 365, 52, 161, 432, 427, 282, 394, 307, 181, 428, 95, 65, 401, 119, 156, 169, 331, 202, 85, 463, 476, 280, 301, 408, 286, 213, 18, 51, 144, 412, 444, 102, 244, 160, 94, 214, 346, 351, 255, 415, 457, 438, 429, 303, 400, 360, 296, 316, 419, 35, 242, 266, 222, 395, 300, 219, 145, 257, 473, 45, 225, 477, 159, 252, 326, 298, 78, 41, 62, 430, 474, 372, 453, 186, 44, 6, 27, 446, 223, 4, 284, 413, 91, 483, 71, 197, 48, 130, 81, 10, 162, 212, 385, 116, 106, 82, 3, 42, 93, 241, 362, 50, 312, 178, 272, 112, 488, 439, 20, 409, 338, 262, 407]

number of elements in route 500
least cost achieved: 25334.576112222276