인공지능 HW5

20162874 이준협

목차

1. 샘플 분석
   -1 Simulated Annealing
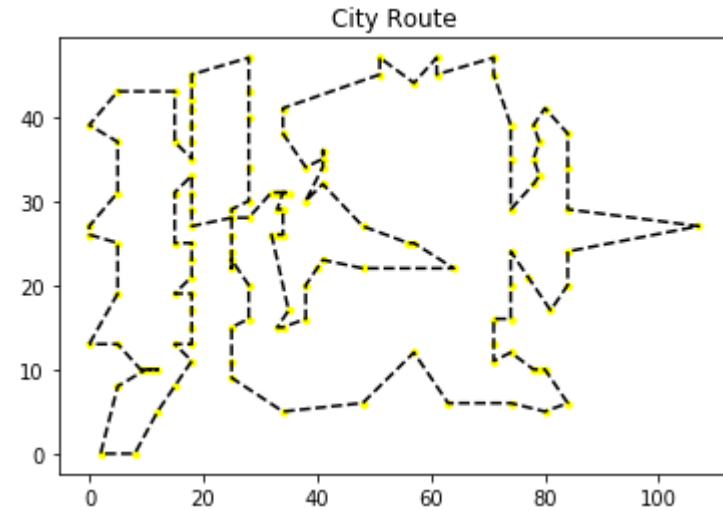
2. 알고리즘 개선
   -1 Simulated Annealing

샘플 분석 – Simulated Annealing data1

Execution time : 42.80213117599487

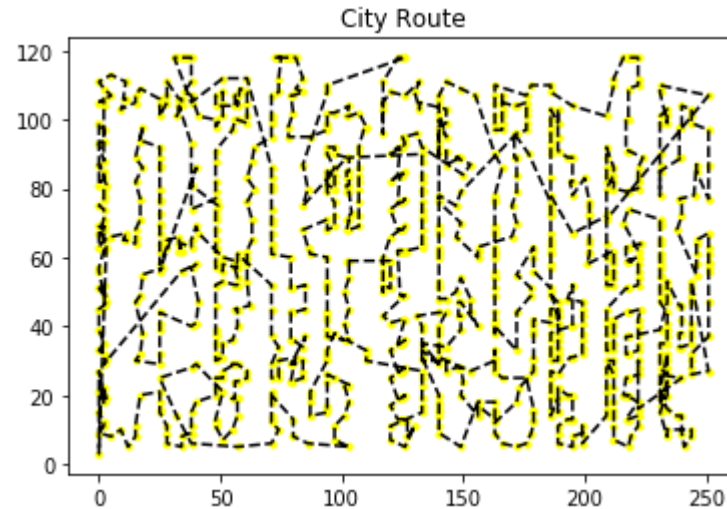Cost : 598.190793574051

City Route

Path : [0, 6, 7, 1, 2, 8, 9, 3, 10, 23, 22, 37, 38, 39, 40, 41, 42, 43, 60, 59, 58, 57, 56, 51, 49, 48, 46, 47, 54, 53, 45, 44, 52, 73, 88, 92, 97, 111, 122, 129, 120, 117, 113, 104, 99, 100, 101, 105, 106, 107, 112, 123, 124, 125, 130, 126, 127, 128, 121, 116, 119, 115, 118, 114, 108, 109, 110, 102, 103, 95, 96, 94, 90, 89, 72, 71, 79, 84, 85, 83, 78, 82, 87, 91, 93, 98, 86, 81, 80, 77, 76, 67, 63, 74, 61, 64, 68, 69, 65, 70, 75, 66, 62, 55, 50, 33, 34, 35, 36, 21, 20, 32, 31, 30, 19, 29, 28, 27, 26, 18, 25, 24, 17, 12, 4, 11, 14, 16, 15, 13, 5, 0]

샘플 분석 – Simulated Annealing data2

Execution time : 172.93491291999817

Cost : 4778.5124295494

City Route

Path : [0, 22, 21, 47, 19, 46, 48, 20, 16, 44, 45, 17, 53, 43, 42, 41, 15, 40, 39, 13, 12, 36, 56, 65, 61, 64, 72, 73, 74, 82, 83, 76, 87, 77, 88, 84, 116, 115, 114, 113, 112, 111, 110, 109, 108, 107, 106, 105, 104, 103, 123, 124, 135, 134, 141, 133, 142, 158, 159, 168, 172, 218, 234, 247, 217, 216, 190, 191, 192, 193, 194, 195, 196, 197, 198, 205, 161, 169, 102, 117, 86, 81, 71, 85, 80, 70, 97, 98, 99, 100, 101, 155, 166, 171, 156, 167, 140, 29, 50, 30, 6, 31, 7, 8, 32, 51, 34, 9, 33, 10, 11, 35, 38, 37, 14, 52, 5, 3, 4, 27, 49, 28, 26, 2, 25, 24, 18, 57, 58, 66, 75, 69, 79, 95, 94, 93, 92, 120, 125, 122, 139, 143, 162, 150, 153, 164, 179, 180, 181, 211, 212, 230, 222, 241, 256, 255, 240, 229, 228, 221, 239, 238, 220, 219, 176, 177, 178, 210, 165, 154, 96, 129, 157, 244, 285, 301, 273, 274, 275, 276, 277, 279, 278, 326, 332, 348, 425, 394, 390, 403, 421, 404, 409, 422, 391, 364, 363, 362, 361, 360, 351, 352, 353, 354, 365, 366, 367, 368, 392, 405, 369, 370, 371, 372, 373, 374, 375, 376, 377, 355, 349, 342, 379, 378, 393, 395, 396, 380, 383, 399, 398, 397, 381, 382, 400, 384, 385, 402, 401, 418, 343, 350, 344, 358, 359, 510, 496, 476, 453, 461, 451, 452, 462, 509, 533, 527, 531, 532, 601, 611, 600, 593, 594, 615, 630, 712, 720, 721, 714, 715, 716, 702, 699, 690, 691, 688, 689, 696, 695, 686, 687, 647, 649, 648, 650, 717, 723, 746, 745, 815, 848, 878, 879, 903, 907, 921, 935, 937, 938, 942, 941, 940, 920, 919, 906, 918, 934, 966, 963, 962, 961, 960, 917, 933, 899, 900, 872, 873, 874, 875, 876, 902, 901, 871, 870, 869, 822, 778, 779, 780, 781, 782, 784, 783, 743, 744, 804, 785, 803, 802, 808, 814, 826, 825, 813, 823, 838, 847, 846, 845, 844, 843, 842, 841, 840, 839, 897, 896, 895, 894, 893, 892, 863, 864, 865, 866, 867, 868, 1069, 969, 968, 1020, 1001, 1002, 967, 999, 998, 997, 995, 996, 1040, 1029, 1030, 1042, 1031, 1046, 1045, 1060, 1082, 1081, 1080, 1067, 1068, 1061, 1028, 1039, 1038, 1022, 1062, 1063, 1064, 1065, 1066, 1079, 1078, 1077, 1076, 1075, 1074, 1073, 1072, 1071, 1050, 1049, 1048, 1047, 1070, 1058, 1057, 1056, 1055, 1054, 1053, 1052, 1051, 1034, 1025, 1026, 1035, 1036, 1037, 1027, 1018, 1017, 1016, 1015, 980, 926, 912, 911, 925, 949, 950, 951, 952, 953, 964, 927, 913, 891, 890, 889, 888, 887, 857, 858, 859, 860, 861, 862, 914, 929, 954, 955, 956, 957, 930, 958, 915, 916, 931, 965, 959, 905, 932, 994, 993, 992, 991, 990, 989, 988, 987, 986, 985, 984, 983, 982, 981, 1014, 1013, 1012, 1011, 1010, 979, 978, 977, 976, 1006, 1007, 1008, 1009, 973, 1003, 1021, 1023, 1032, 1041, 1043, 1059, 1044, 1000, 1019, 970, 1004, 1005, 971, 972, 974, 975, 1024,
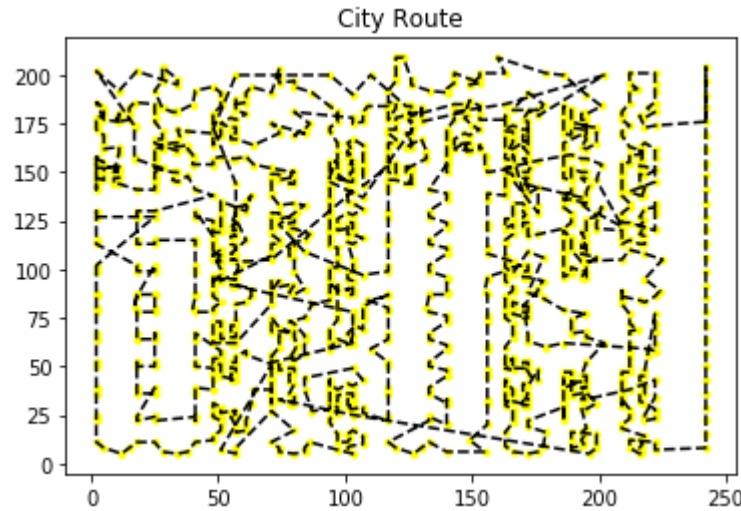
샘플 분석 – Simulated Annealing data2

1033, 944, 948, 947, 946, 924, 910, 904, 923, 909, 945, 908, 922, 943, 939, 936, 928, 898, 877, 880, 882, 881, 883, 884, 856, 886, 885, 855, 854, 853, 852, 851, 850, 849, 836, 827, 837, 824, 820, 800, 801, 786, 805, 809, 816, 817, 810, 806, 789, 787, 788, 747, 748, 749, 750, 751, 752, 753, 790, 811, 818, 828, 829, 830, 831, 833, 832, 834, 835, 807, 821, 819, 812, 758, 757, 756, 755, 754, 791, 792, 793, 794, 795, 799, 762, 763, 797, 796, 798, 761, 760, 759, 738, 737, 736, 735, 734, 733, 732, 731, 713, 703, 651, 684, 693, 706, 719, 726, 727, 729, 728, 730, 718, 692, 657, 658, 659, 662, 661, 660, 634, 574, 575, 576, 577, 578, 579, 606, 580, 529, 545, 544, 540, 604, 603, 612, 617, 623, 632, 622, 639, 640, 641, 652, 653, 654, 655, 656, 642, 627, 595, 566, 567, 568, 569, 571, 570, 572, 541, 542, 573, 543, 605, 624, 625, 618, 619, 626, 643, 635, 636, 628, 613, 607, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 629, 614, 644, 645, 646, 697, 708, 698, 709, 710, 711, 700, 701, 722, 777, 776, 775, 774, 773, 772, 771, 770, 769, 768, 767, 766, 765, 764, 739, 740, 741, 742, 707, 725, 724, 705, 704, 665, 664, 663, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 680, 679, 678, 681, 682, 683, 694, 685, 638, 621, 602, 565, 564, 563, 562, 610, 561, 599, 598, 597, 596, 609, 608, 631, 620, 616, 637, 633, 560, 530, 523, 508, 522, 507, 475, 485, 495, 484, 474, 521, 506, 494, 483, 493, 505, 520, 473, 482, 492, 504, 519, 471, 460, 459, 458, 457, 455, 456, 468, 469, 470, 411, 427, 426, 407, 424, 406, 423, 410, 449, 448, 447, 539, 538, 537, 536, 535, 534, 463, 472, 517, 528, 526, 524, 511, 486, 497, 477, 464, 512, 498, 487, 478, 465, 513, 499, 488, 479, 466, 514, 500, 489, 480, 515, 501, 467, 454, 516, 502, 490, 481, 491, 503, 518, 525, 546, 549, 548, 547, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 434, 433, 417, 416, 432, 431, 415, 414, 430, 435, 413, 429, 412, 428, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 450, 436, 419, 408, 420, 389, 357, 388, 387, 386, 356, 313, 314, 323, 315, 324, 336, 333, 337, 334, 325, 316, 312, 311, 310, 304, 300, 299, 309, 303, 302, 272, 271, 270, 298, 297, 269, 267, 262, 268, 261, 266, 265, 260, 259, 258, 257, 264, 231, 243, 242, 223, 214, 213, 182, 183, 184, 185, 186, 187, 188, 189, 215, 232, 245, 246, 233, 248, 249, 284, 283, 282, 308, 281, 280, 305, 306, 307, 335, 317, 327, 338, 339, 340, 328, 318, 345, 341, 329, 319, 320, 330, 346, 347, 331, 321, 322, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 254, 209, 148, 126, 128, 138, 132, 145, 146, 147, 152, 151, 144, 149, 170, 173, 204, 206, 207, 208, 175, 174, 226, 227, 237, 236, 250, 253, 252, 251, 263, 235, 225, 224, 203, 202, 201, 200, 199, 160, 163, 130, 127, 136, 137, 131, 121, 119, 118, 89, 90, 91, 78, 68, 67, 59, 62, 60, 63, 55, 1, 23, 54, 0]

샘플 분석 – Simulated Annealing data3

Execution time : 243.65151262283325

Cost : 7152.20059266424

City Route

Path : [0, 37, 36, 35, 34, 33, 32, 31, 30, 29, 27, 28, 26, 25, 1, 49, 70, 75, 83, 103, 153, 172, 178, 186, 215, 221, 281, 288, 289, 236, 237, 238, 239, 240, 291, 290, 317, 371, 338, 370, 337, 316, 368, 360, 395, 400, 401, 407, 412, 442, 441, 440, 439, 438, 437, 443, 444, 445, 446, 447, 448, 449, 483, 482, 502, 517, 539, 538, 516, 501, 500, 537, 499, 536, 535, 515, 498, 481, 733, 1386, 1399, 1388, 1394, 1286, 1275, 1301, 1325, 1328, 1308, 1334, 1314, 1370, 1319, 1373, 1398, 1322, 1345, 1376, 1346, 1377, 1378, 1347, 1324, 1379, 1404, 1380, 1381, 1298, 1299, 1300, 1348, 1382, 1267, 1203, 1184, 1201, 1153, 1101, 999, 1000, 1001, 1002, 1003, 1004, 1005, 1067, 1068, 1006, 1007, 1008, 1009, 1069, 1070, 1071, 1107, 1133, 1106, 1132, 1105, 1156, 1131, 1104, 1103, 1130, 1155, 1154, 1189, 1223, 1276, 1277, 1278, 1224, 1225, 1281, 1280, 1228, 1227, 1226, 1279, 1358, 1332, 1309, 1391, 1357, 1356, 1355, 1307, 1354, 1330, 1305, 1306, 1331, 1353, 1352, 1329, 1304, 1387, 1351, 1383, 1349, 1326, 1384, 1350, 1327, 1271, 1302, 1268, 1269, 1270, 1209, 1210, 1211, 1212, 1213, 1214, 1215, 1216, 1217, 1218, 1219, 1220, 1221, 1222, 1274, 1273, 1272, 1303, 1405, 1455, 1515, 1569, 1537, 1568, 1567, 1536, 1504, 1453, 1454, 1452, 1451, 1450, 1481, 1480, 1484, 1479, 1478, 1477, 1476, 1475, 1474, 1449, 1448, 1447, 1446, 1445, 1444, 1443, 1442, 1441, 1438, 1439, 1440, 1472, 1471, 1470, 1437, 1434, 1522, 1487, 1505, 1503, 1514, 1502, 1482, 1457, 1541, 1564, 1595, 1577, 1586, 1587, 1588, 1589, 1590, 1591, 1592, 1593, 1594, 1596, 1597, 1598, 1570, 1571, 1572, 1573, 1574, 1575, 1576, 1578, 1579, 1580, 1585, 1584, 1583, 1582, 1581, 1550, 1527, 1497, 1528, 1551, 1538, 1552, 1553, 1554, 1555, 1469, 1468, 1483, 1467, 1466, 1436, 1435, 1433, 1432, 1465, 1431, 1430, 1464, 1511, 1510, 1494, 1493, 1509, 1525, 1547, 1524, 1492, 1491, 1523, 1508, 1521, 1490, 1461, 1546, 1548, 1549, 1526, 1496, 1495, 1463, 1462, 1429, 1428, 1427, 1426, 1425, 1424, 1423, 1422, 1421, 1420, 1419, 1418, 1460, 1459, 1417, 1416, 1415, 1414, 1413, 1458, 1542, 1543, 1545, 1544, 1520, 1489, 1519, 1488, 1507, 1518, 1486, 1517, 1516, 1506, 1485, 1456, 1406, 1407, 1408, 1409, 1410, 1411, 1389, 1390, 1400, 1392, 1412, 1393, 1401, 1363, 1337, 1313, 1285, 1193, 1019, 1074, 985, 974, 975, 976, 966, 965, 957, 937, 946, 951, 952, 958, 959, 953, 938, 939, 947, 960, 967, 964, 948, 954, 949, 872, 875, 873, 874, 853, 845, 838, 828, 827, 826, 799, 798, 825, 824, 797, 796, 795, 794, 793, 792, 791, 823, 822, 821, 788, 789, 790, 755, 756, 757, 758, 759, 760, 761, 762, 728, 680,

샘플 분석 – Simulated Annealing data3

703, 702, 679, 678, 701, 727, 700, 726, 699, 725, 724, 698, 697, 723, 722, 696, 643, 676, 644, 646, 647, 648, 600, 599, 598, 595, 597, 596, 649, 650, 651, 601, 602, 652, 653, 654, 603, 568, 533, 534, 478, 479, 480, 435, 406, 399, 398, 397, 366, 367, 365, 396, 364, 315, 283, 314, 336, 363, 362, 335, 313, 312, 334, 361, 411, 476, 477, 434, 554, 530, 555, 567, 532, 731, 730, 763, 764, 765, 775, 804, 803, 802, 801, 800, 829, 830, 805, 806, 831, 832, 833, 834, 836, 837, 839, 868, 867, 888, 921, 922, 943, 944, 945, 963, 971, 962, 972, 973, 1036, 998, 1207, 1249, 1372, 1402, 1371, 1342, 1318, 1317, 1341, 1369, 1368, 1366, 1367, 1339, 1289, 1288, 1287, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1248, 1292, 1291, 1290, 1340, 1316, 1397, 1396, 1395, 1364, 1315, 1365, 1338, 1239, 1238, 1237, 1236, 1235, 1234, 1233, 1232, 1231, 1230, 1229, 1282, 1283, 1284, 1312, 1336, 1362, 1361, 1335, 1311, 1385, 1360, 1359, 1333, 1310, 1109, 1159, 1135, 1110, 1111, 1136, 1160, 1187, 1112, 1137, 1161, 1162, 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624, 662, 663, 664, 665, 667, 629, 628, 627, 626, 625, 570, 562, 505, 545, 561, 560, 558, 541, 503, 542, 550, 543, 544, 518, 455, 456, 457, 458, 459, 460, 488, 504, 487, 486, 485, 453, 454, 452, 451, 741, 686, 749, 769, 770, 771, 772, 773, 818, 817, 776, 816, 815, 814, 813, 778, 812, 811, 810, 809, 808, 807, 766, 767, 734, 704, 705, 735, 681, 682, 706, 736, 737, 707, 683, 658, 657, 609, 610, 611, 612, 613, 614, 617, 616, 615, 659, 684, 738, 768, 739, 557, 556, 569, 607, 608, 656, 655, 606, 605, 645, 638, 668, 695, 677, 729, 754, 750, 710, 687, 740, 661, 565, 563, 559, 540, 484, 489, 417, 531, 436, 383, 375, 300, 450, 402, 403, 377, 376, 342, 321, 320, 341, 374, 373, 340, 319, 318, 339, 372, 292, 293, 294, 247, 248, 249, 295, 296, 297, 200, 199, 198, 197, 246, 245, 244, 243, 242, 241, 196, 195, 193, 194, 131, 132, 90, 91, 134, 133, 92, 93, 95, 94, 135, 136, 138, 137, 96, 97, 98, 139, 140, 141, 142, 100, 81, 99, 102, 143, 101, 82, 2, 3, 5, 4, 106, 0]

느낀점

- 확률적 접근을 통해 선택적으로 bad moves를 허락해 dynamic programming처럼 현재 greedy하지 않은 선택이지만 후에 더 큰 이득을 위해 bad moves를 하는 것이 신기했다.

- 하지만 언제 bad moves를 해주어야 할지에 대해 고려해줄 수 없으니까 확률적으로 접근하고 있는 것이지만 이것이 최적의 moves를 하도록 크게 도와주고 있는 것 같지는 않다고 생각했다.

Improvement

- 위에서 bad moves를 확률적으로 선택해 나가는것은 알겠지만 상당히 안좋은 bad moves를 선택하는것을 피하면 어떨까 하는것이 생각났다.

- VERYBAD라는 변수를 통해서 new cost와 best cost의 차이가 점점 작아질때만 선택하도록 바꾸어 갑자기 큰 bad moves를 선택하지 않도록 바꾸어주었다.

- Accept rate도 추가하여 언제나 작아지지 않고 어느정도 넉넉하게 받아들이도록 하였다.(코드참고)

Improvement

- 추가로 cooling ratio를 여러 개 가지는 cooling list를 만드는 접근도 해보았지만 이는 단순히 cooling ratio에 대한 optimal search밖에 안된다는 생각을 했다.
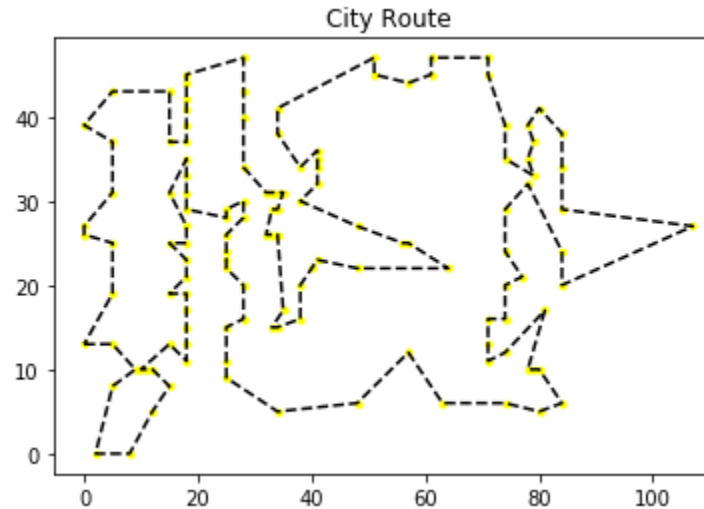
변화

- def simulated_annealing(path_map, path):

-     best_path = path.copy()

-     best_cost = path_cost(path_map, best_path).sum()

-     global TEMPERATURE

-     global VERYBAD

-     while TEMPERATURE > 1:

-         curr_path = best_path.copy()

-         new_path, new_cost = two_opt_swap(path_map, curr_path, SUB_STEPS)

-         if new_cost < best_cost:

-             best_path = new_path

-             best_cost = new_cost

-         else:

-             cost_diff = new_cost-best_cost

-             if VERYBAD>cost_diff:

-                 VERYBAD=cost_diff

-                 prob = np.exp(-cost_diff / float(TEMPERATURE))

-                 if prob > np.random.rand(1):

-                     best_path = new_path

-                     best_cost = new_cost

-             TEMPERATURE = TEMPERATURE * COOLING_RATIO

-     return best_path, best_cost

improve – Simulated Annealing data1

Execution time : 23.314407110214233

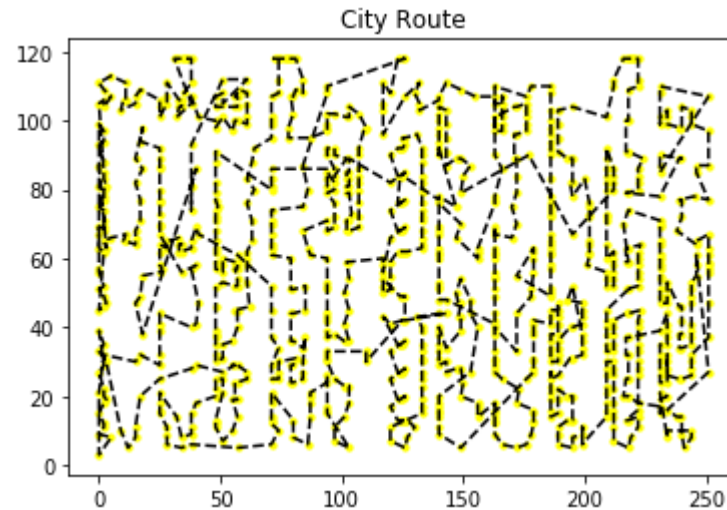Cost : 605.5362547824743

City Route

Path : [0, 5, 13, 11, 4, 12, 17, 24, 16, 15, 14, 18, 25, 26, 27, 28, 29, 19, 30, 31, 20, 32, 33, 21, 37, 36, 35, 34, 50, 51, 56, 55, 49, 48, 47, 46, 54, 53, 45, 44, 52, 73, 88, 92, 97, 111, 122, 129, 120, 117, 113, 123, 104, 99, 100, 101, 105, 106, 112, 107, 108, 114, 125, 124, 130, 126, 127, 128, 121, 116, 119, 115, 118, 109, 110, 102, 103, 96, 95, 94, 89, 90, 72, 71, 79, 85, 84, 83, 82, 78, 87, 91, 93, 98, 86, 81, 80, 77, 76, 67, 63, 74, 68, 64, 61, 65, 69, 75, 70, 66, 62, 57, 58, 59, 60, 43, 42, 41, 40, 39, 38, 22, 23, 10, 3, 9, 8, 2, 1, 7, 6, 0]

improve– Simulated Annealing data2

Execution Time: 152.89809608459473

Cost: 4547.287470133042

City Route

Path: [0, 22, 21, 54, 23, 1, 55, 63, 62, 60, 59, 67, 68, 78, 91, 90, 89, 118, 119, 121, 131, 137, 136, 130, 127, 148, 126, 128, 132, 138, 145, 146, 147, 152, 151, 144, 149, 170, 173, 204, 206, 224, 225, 235, 263, 251, 252, 253, 250, 227, 237, 236, 226, 174, 175, 208, 207, 254, 209, 163, 160, 161, 169, 85, 71, 81, 86, 102, 117, 103, 104, 105, 123, 124, 135, 142, 134, 133, 141, 158, 159, 168, 172, 249, 284, 283, 282, 308, 281, 280, 305, 306, 307, 335, 328, 318, 317, 327, 338, 339, 340, 345, 341, 329, 319, 320, 330, 346, 347, 331, 321, 322, 286, 287, 288, 289, 290, 291, 292, 343, 350, 344, 358, 359, 510, 496, 476, 462, 453, 452, 451, 461, 509, 533, 527, 532, 531, 564, 565, 602, 621, 638, 649, 648, 690, 691, 689, 688, 696, 695, 686, 687, 647, 699, 702, 716, 715, 714, 721, 720, 712, 701, 700, 711, 710, 709, 698, 708, 697, 678, 679, 680, 677, 676, 675, 674, 673, 672, 671, 670, 669, 668, 667, 666, 607, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 629, 614, 644, 645, 646, 681, 682, 683, 694, 685, 650, 717, 723, 746, 745, 744, 743, 784, 783, 782, 781, 780, 779, 778, 777, 776, 775, 774, 773, 772, 771, 770, 769, 768, 767, 766, 765, 764, 763, 762, 707, 742, 741, 740, 739, 725, 724, 705, 704, 665, 664, 663, 662, 661, 660, 659, 658, 657, 692, 713, 703, 730, 729, 728, 727, 726, 719, 706, 693, 684, 651, 652, 653, 654, 655, 656, 639, 640, 641, 642, 622, 632, 623, 617, 612, 603, 604, 573, 574, 575, 576, 577, 578, 579, 605, 624, 625, 618, 626, 619, 613, 628, 636, 635, 643, 634, 572, 571, 570, 569, 568, 567, 566, 595, 627, 718, 731, 732, 733, 734, 735, 736, 737, 738, 759, 760, 761, 798, 799, 797, 796, 795, 758, 757, 756, 755, 754, 791, 792, 793, 794, 812, 819, 832, 833, 834, 835, 807, 821, 831, 830, 829, 828, 818, 811, 790, 752, 753, 751, 750, 749, 748, 747, 787, 788, 789, 806, 810, 817, 816, 809, 805, 786, 801, 800, 820, 824, 837, 827, 836, 849, 850, 851, 852, 853, 854, 855, 856, 886, 885, 884, 883, 882, 881, 880, 877, 898, 928, 936, 939, 943, 922, 908, 944, 946, 947, 948, 949, 950, 951, 952, 953, 964, 927, 913, 891, 890, 889, 888, 887, 857, 858, 859, 860, 861, 862, 929, 914, 954, 955, 956, 957, 958, 959, 965, 931, 916, 915, 930, 905, 932, 994, 993, 992, 991, 990, 989, 988, 987, 986, 985, 984, 983, 982, 981, 1015, 1016, 1017, 1018, 1027, 1037, 1036, 1035, 1026, 1025, 1034, 1051, 1052, 1053, 1054, 1055, 1056, 1057, 1058, 1062, 1063, 1064, 1070, 1003, 1021, 1023, 1032, 1041, 1043, 1059, 1044, 1000, 1019, 973, 1004, 972, 970, 971, 945, 923, 909, 904, 910, 924, 925, 911, 912, 926, 980, 1014, 1013, 1012, 1011, 1010, 979, 978, 977, 976, 975, 974, 1005, 1009, 1008, 1007, 1006, 1024, 1033, 1047,
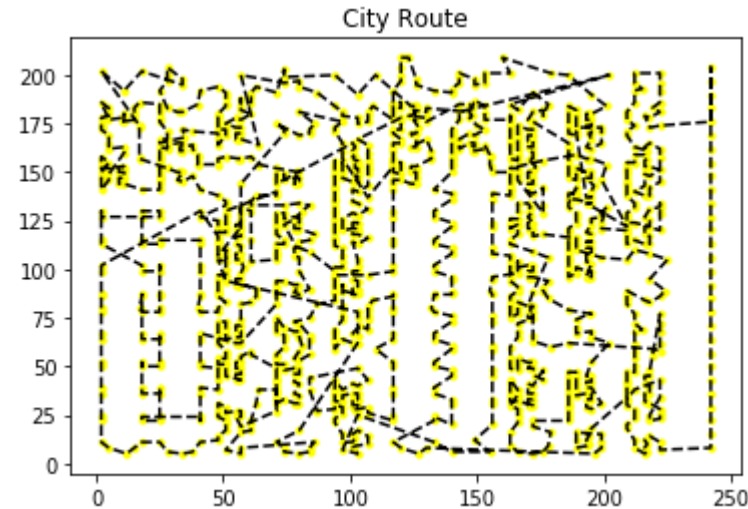
improve– Simulated Annealing data2

1048, 1049, 1050, 1071, 1072, 1073, 1074, 1075, 1076, 1077, 1078, 1079, 1066, 1065, 1022, 1038, 1039, 1028, 1061, 1080, 1067, 1068, 1081, 1082, 1060, 1045, 1046, 1031, 1042, 1030, 1020, 1001, 1002, 967, 999, 968, 969, 1069, 996, 997, 998, 1040, 1029, 995, 917, 933, 960, 961, 962, 963, 966, 934, 918, 906, 919, 920, 940, 941, 942, 938, 937, 935, 921, 907, 903, 879, 878, 848, 815, 785, 804, 803, 802, 808, 814, 826, 825, 813, 823, 838, 847, 846, 845, 844, 843, 842, 841, 840, 839, 865, 864, 863, 892, 893, 894, 895, 896, 897, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 902, 901, 900, 899, 822, 722, 630, 633, 637, 631, 620, 616, 608, 609, 610, 611, 601, 563, 562, 561, 600, 599, 598, 596, 597, 615, 594, 593, 506, 521, 474, 434, 433, 417, 416, 432, 431, 415, 414, 430, 435, 429, 413, 412, 428, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 450, 436, 420, 419, 408, 389, 357, 388, 387, 386, 356, 313, 314, 323, 315, 324, 333, 336, 337, 334, 325, 316, 312, 311, 310, 309, 299, 300, 304, 303, 302, 272, 271, 270, 298, 297, 269, 267, 262, 268, 261, 266, 265, 260, 259, 258, 257, 264, 231, 243, 242, 223, 214, 213, 182, 183, 184, 185, 186, 187, 188, 189, 215, 232, 245, 246, 233, 247, 248, 234, 218, 217, 216, 190, 191, 192, 193, 194, 195, 196, 197, 198, 205, 199, 200, 201, 202, 203, 293, 294, 295, 296, 400, 384, 385, 402, 401, 418, 399, 398, 383, 382, 381, 397, 380, 396, 395, 393, 378, 379, 342, 349, 355, 377, 376, 375, 374, 373, 372, 371, 370, 369, 392, 405, 410, 423, 406, 424, 407, 426, 411, 427, 460, 459, 458, 471, 519, 504, 492, 482, 473, 520, 505, 493, 483, 494, 484, 475, 485, 495, 507, 522, 508, 523, 530, 560, 559, 558, 557, 556, 555, 554, 553, 552, 551, 550, 549, 548, 547, 546, 525, 518, 503, 491, 481, 470, 469, 468, 455, 456, 457, 490, 502, 516, 515, 606, 580, 529, 545, 544, 543, 542, 541, 540, 539, 538, 537, 536, 535, 534, 463, 472, 517, 526, 528, 524, 511, 497, 486, 477, 464, 512, 498, 487, 478, 465, 513, 499, 488, 479, 466, 514, 500, 489, 480, 454, 467, 501, 447, 448, 449, 368, 367, 366, 365, 391, 404, 409, 422, 421, 403, 390, 394, 425, 360, 361, 362, 364, 363, 354, 353, 352, 351, 348, 332, 326, 279, 278, 277, 276, 275, 274, 273, 301, 285, 244, 157, 139, 122, 125, 120, 92, 93, 94, 95, 129, 143, 162, 150, 153, 164, 179, 180, 181, 211, 210, 178, 177, 176, 219, 220, 238, 221, 239, 228, 229, 240, 255, 256, 241, 222, 230, 212, 165, 154, 96, 79, 69, 75, 66, 58, 50, 6, 31, 7, 29, 4, 28, 27, 49, 26, 2, 25, 24, 18, 57, 5, 3, 30, 70, 80, 97, 98, 99, 100, 101, 155, 166, 171, 156, 167, 140, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 84, 88, 77, 87, 76, 83, 82, 74, 73, 72, 64, 61, 65, 56, 36, 52, 17, 46, 19, 47, 48, 20, 16, 12, 35, 8, 32, 51, 33, 9, 34, 10, 11, 13, 14, 38, 37, 39, 40, 15, 41, 42, 43, 53, 44, 45, 0]

improve– Simulated Annealing data3

Execution Time: 180.39799165725708

Cost: 6846.257682937014

City Route

Path: [0, 37, 36, 35, 34, 33, 32, 31, 30, 29, 28, 27, 26, 25, 1, 49, 70, 75, 83, 103, 153, 172, 178, 186, 215, 221, 281, 288, 289, 236, 237, 238, 239, 240, 291, 290, 317, 338, 371, 370, 337, 316, 368, 436, 443, 444, 445, 446, 447, 448, 449, 402, 403, 377, 376, 342, 321, 320, 341, 374, 373, 340, 319, 318, 339, 372, 292, 293, 294, 247, 248, 249, 295, 296, 297, 250, 251, 252, 253, 254, 255, 256, 257, 302, 301, 299, 298, 323, 344, 379, 380, 345, 324, 325, 346, 381, 382, 384, 404, 408, 409, 385, 347, 326, 327, 348, 386, 387, 388, 349, 328, 306, 307, 329, 350, 351, 308, 309, 330, 352, 353, 358, 476, 477, 434, 530, 554, 555, 567, 532, 652, 602, 601, 651, 650, 649, 753, 790, 789, 788, 821, 822, 823, 791, 792, 793, 794, 795, 796, 797, 824, 825, 798, 799, 826, 827, 828, 728, 762, 761, 760, 759, 758, 757, 756, 755, 721, 675, 674, 720, 752, 719, 673, 642, 641, 640, 671, 693, 717, 718, 694, 672, 670, 692, 716, 751, 715, 669, 714, 713, 748, 712, 691, 690, 747, 746, 711, 689, 688, 709, 745, 666, 667, 665, 664, 663, 662, 624, 623, 622, 621, 620, 619, 618, 660, 685, 708, 741, 531, 417, 489, 484, 540, 559, 563, 565, 383, 375, 300, 360, 395, 400, 401, 407, 412, 442, 441, 440, 439, 438, 437, 481, 498, 515, 535, 536, 499, 537, 500, 501, 516, 538, 539, 517, 502, 482, 483, 450, 451, 452, 453, 454, 485, 486, 487, 455, 456, 457, 458, 459, 460, 488, 504, 518, 544, 543, 550, 542, 503, 541, 558, 560, 561, 545, 505, 562, 570, 625, 626, 627, 628, 629, 630, 631, 632, 633, 774, 819, 779, 781, 782, 783, 784, 785, 786, 787, 820, 840, 847, 856, 857, 858, 848, 841, 842, 849, 859, 877, 878, 879, 871, 843, 850, 860, 861, 844, 851, 862, 869, 852, 863, 864, 854, 874, 875, 949, 954, 948, 964, 967, 960, 947, 939, 938, 937, 946, 953, 959, 958, 952, 951, 957, 965, 966, 976, 975, 974, 985, 1018, 1017, 1016, 1015, 1014, 1013, 1012, 1011, 1010, 984, 983, 982, 981, 980, 979, 1003, 1002, 1001, 1000, 999, 1064, 1063, 1062, 1061, 1100, 1099, 1059, 1058, 1057, 1056, 1055, 1054, 1053, 1052, 1096, 1097, 1098, 1126, 1184, 1201, 1153, 1004, 1005, 1067, 1068, 1006, 1007, 1008, 1009, 1069, 1070, 1071, 1107, 1133, 1106, 1132, 1105, 1156, 1131, 1104, 1103, 1130, 1155, 1154, 1189, 1274, 1273, 1272, 1387, 1405, 1455, 1515, 1569, 1537, 1568, 1567, 1536, 1504, 1454, 1453, 1452, 1451, 1450, 1481, 1480, 1484, 1479, 1478, 1477, 1476, 1475, 1474, 1449, 1448, 1447, 1446, 1445, 1444, 1443, 1442, 1441, 1370, 1314, 1334, 1308, 1328, 1325, 1301, 1275, 1286, 1394, 1388, 1399, 1386, 876, 870, 835, 780, 889, 890, 923, 924, 925, 891, 892, 926, 927, 893, 894, 928, 930, 895, 896, 931, 932, 897, 880, 898, 899, 933, 934, 935, 936, 900,

improve– Simulated Annealing data3

881, 901, 902, 883, 884, 903, 904, 885, 886, 905, 906, 887, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 940, 941, 1403, 1035, 1082, 1170, 1202, 1194, 1195, 1168, 1117, 1167, 1239, 1238, 1237, 1236, 1235, 1234, 1233, 1232, 1231, 1230, 1229, 1282, 1283, 1284, 1312, 1336, 1362, 1361, 1335, 1311, 1385, 1360, 1359, 1333, 1310, 1288, 1287, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1248, 1292, 1291, 1290, 1289, 1397, 1396, 1395, 1364, 1315, 1365, 1338, 1366, 1367, 1339, 1316, 1340, 1368, 1369, 1341, 1317, 1318, 1342, 1371, 1402, 1372, 1249, 1207, 998, 1036, 973, 972, 971, 962, 963, 945, 944, 943, 922, 921, 888, 867, 868, 839, 837, 836, 834, 833, 832, 831, 806, 805, 830, 829, 804, 803, 802, 801, 800, 775, 765, 764, 763, 730, 731, 653, 654, 603, 568, 533, 534, 478, 369, 411, 361, 334, 312, 313, 335, 362, 363, 336, 314, 283, 315, 364, 396, 365, 367, 366, 397, 398, 399, 406, 435, 480, 479, 604, 732, 777, 846, 855, 866, 865, 853, 845, 838, 873, 872, 942, 950, 955, 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205, 269, 270, 271, 268, 305, 267, 266, 265, 264, 263, 262, 261, 260, 303, 259, 258, 201, 184, 202, 203, 204, 185, 187, 188, 105, 104, 84, 85, 86, 87, 107, 106, 4, 5, 3, 2, 82, 101, 143, 102, 142, 141, 140, 139, 98, 81, 99, 100, 97, 96, 137, 138, 136, 135, 94, 95, 93, 92, 133, 134, 132, 131, 90, 91, 194, 193, 195, 196, 241, 242, 243, 244, 245, 246, 197, 198, 199, 200, 322, 343, 378, 461, 462, 463, 464, 465, 466, 467, 490, 507, 519, 547, 506, 546, 564, 548, 520, 491, 492, 508, 470, 525, 524, 510, 494, 493, 509, 523, 566, 552, 522, 521, 551, 634, 571, 635, 636, 637, 639, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 648, 647, 646, 644, 643, 676, 696, 722, 723, 697, 698, 724, 725, 699, 700, 726, 727, 701, 678, 702, 679, 703, 680, 429, 430, 431, 432, 475, 474, 497, 513, 528, 527, 512, 496, 514, 529, 433, 410, 394, 359, 333, 279, 223, 222, 179, 180, 181, 182, 175, 176, 166, 160, 159, 165, 167, 161, 156, 146, 145, 122, 121, 120, 119, 118, 117, 116, 115, 114, 113, 112, 111, 110, 109, 108, 88, 60, 54, 50, 51, 55, 61, 62, 56, 52, 53, 57, 63, 40, 12, 13, 14, 15, 16, 17, 41, 11, 10, 9, 8, 7, 6, 38, 39, 64, 65, 42, 43, 44, 18, 19, 20, 21, 22, 46, 47, 48, 23, 45, 59, 67, 68, 66, 58, 71, 72, 73, 74, 80, 129, 128, 127, 126, 125, 148, 147, 124, 123, 173, 168, 177, 227, 226, 225, 224, 280, 282, 228, 229, 230, 231, 232, 233, 234, 284, 285, 286, 287, 235, 192, 183, 169, 162, 157, 149, 130, 150, 151, 152, 171, 170, 89, 69, 24, 79, 78, 77, 76, 144, 155, 158, 164, 154, 163, 174, 191, 220, 278, 277, 189, 219, 218, 217, 216, 214, 272, 273, 274, 275, 276, 428, 427, 405, 393, 392, 473, 526, 553, 549, 511, 495, 471, 472, 426, 425, 424, 423, 422, 421, 420, 469, 468, 419, 418, 416, 415, 414, 413, 389, 390, 391, 357, 356, 355, 354, 332, 311, 310, 331, 206, 207, 208, 209, 210, 211, 212, 213, 190, 0]

Result

- Data 1에 대해서는 기존의 코드보다 improve 되지않았지만

- Data 2, Data 3 같은 경우에는 기존 코드보다 훨씬 좋은 성능을 내고있음을 확인하였다.

- 상당히 bad한 moves를 막자는 생각이 잘 된것같다.

Result

- Data 1에 대해서는 기존의 코드보다 improve 되지않았지만 (7증가)

- Data 2, Data 3 같은 경우에는 기존 코드보다 훨씬 좋은 성능을 내고있음을 확인하였다.
(각각 200,300 감소)
- Execution time은 모든 코드에 대해서 개선되었다.

- 상당히 bad한 moves를 막자는 생각이 잘 된것같다.