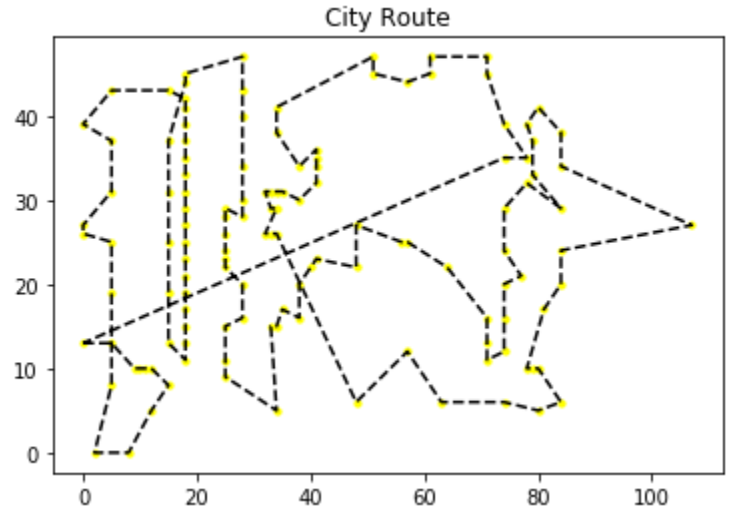
# 인공지능 HW6

20162874 이준협

# 목차

# 샘플 분석 –Genetic Algorithm data1

Execution time : 24.656120777130127



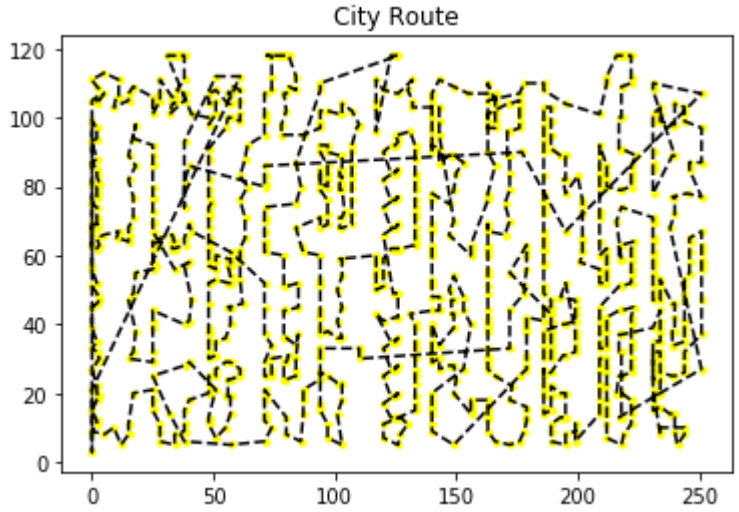

Cost : 671.3770489505793

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

# 샘플 분석 –Genetic Algorithm data2

Execution time : 166.93240237236023

Cost : 4676.153182321315




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, 149, 144, 151, 152, 147, 146, 145, 138, 132, 128, 126, 170, 173, 204, 206, 207, 174, 175, 208, 226, 236, 237, 227, 250, 253, 252, 251, 263, 235, 225, 224, 203, 202, 201, 200, 199, 205, 198, 197, 196, 195, 194, 193, 192, 191, 190, 216, 217, 218, 234, 248, 247, 233, 246, 245, 232, 215, 189, 188, 187, 186, 185, 184, 183, 182, 213, 214, 223, 242, 243, 231, 264, 257, 258, 259, 260, 265, 266, 261, 268, 262, 267, 269, 297, 298, 270, 271, 272, 302, 303, 304, 300, 299, 309, 310, 311, 312, 316, 325, 334, 337, 336, 333, 324, 315, 323, 314, 313, 356, 386, 387, 388, 357, 389, 408, 419, 420, 436, 450, 446, 445, 444, 443, 442, 441, 440, 439, 438, 437, 428, 412, 413, 429, 435, 430, 414, 415, 431, 432, 416, 417, 433, 434, 418, 401, 402, 385, 384, 400, 399, 398, 397, 381, 382, 383, 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, 427, 411, 460, 459, 458, 457, 456, 455, 468, 469, 470, 481, 491, 503, 518, 525, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 530, 523, 508, 522, 507, 495, 485, 475, 484, 494, 506, 521, 474, 483, 493, 505, 520, 473, 482, 492, 504, 519, 471, 490, 502, 516, 515, 501, 467, 454, 480, 489, 500, 514, 466, 479, 488, 499, 513, 465, 478, 487, 498, 512, 464, 477, 486, 497, 511, 524, 528, 526, 517, 472, 463, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 529, 580, 606, 607, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 615, 630, 633, 637, 631, 620, 616, 608, 609, 597, 596, 598, 599, 600, 561, 562, 563, 564, 565, 602, 621, 638, 649, 650, 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, 665, 664, 663, 662, 661, 660, 659, 658, 657, 692, 713, 703, 730, 729, 728, 727, 726, 719, 706, 693, 684, 651, 652,

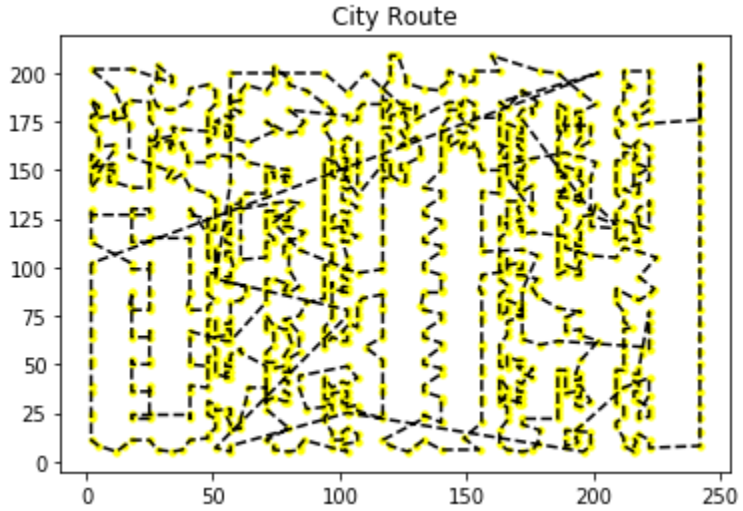
# 샘플 분석 –Genetic Algorithm data2

653, 654, 655, 656, 642, 641, 640, 639, 622, 632, 623, 617, 612, 603, 604, 573, 574, 575, 576, 577, 578, 579, 605, 624, 625, 618, 619, 626, 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, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 743, 744, 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, 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, 745, 746, 723, 717, 648, 685, 694, 683, 682, 681, 646, 645, 644, 614, 629, 610, 611, 601, 531, 532, 527, 533, 509, 462, 453, 452, 451, 461, 476, 496, 510, 359, 358, 344, 350, 343, 292, 291, 290, 289, 288, 287, 286, 322, 321, 331, 347, 346, 330, 320, 319, 329, 341, 345, 340, 339, 338, 327, 317, 318, 328, 335, 307, 306, 305, 280, 281, 308, 282, 283, 284, 249, 172, 168, 159, 158, 141, 133, 134, 142, 135, 124, 123, 105, 104, 103, 117, 102, 86, 81, 71, 85, 80, 70, 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, 35, 12, 13, 14, 38, 37, 39, 40, 15, 41, 42, 43, 53, 44, 45, 17, 46, 19, 47, 48, 20, 16, 11, 10, 34, 9, 33, 51, 32, 8, 7, 31, 6, 30, 50, 29, 4, 28, 27, 49, 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, 222, 230, 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, 278, 279, 326, 332, 348, 351, 352, 353, 354, 363, 364, 391, 404, 409, 422, 421, 403, 425, 394, 390, 360, 361, 362, 365, 366, 367, 368, 449, 448, 447, 704, 705, 724, 725, 739, 740, 741, 742, 707, 797, 796, 795, 794, 793, 792, 791, 754, 755, 756, 757, 758, 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, 944, 945, 923, 909, 904, 910, 924, 946, 947, 948, 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, 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, 1065, 1066, 1079, 1078, 1077, 1076, 1075, 1074, 1073, 1072, 1071, 1050, 1049, 1048, 1047, 1033, 1024, 1006, 1007, 1008, 1009, 978, 977, 976, 975, 974, 1005, 1004, 972, 971, 970, 1003, 1021, 1023, 1032, 1041, 1043, 1059, 1044, 1000, 1019, 973, 979, 1010, 1011, 1012, 1013, 1014, 980, 926, 912, 911, 925, 922, 908, 1070, 1022, 1038, 1039, 1028, 1061, 1080, 1067, 1068, 1081, 1082, 1060, 1045, 1046, 1031, 1042, 1030, 1020, 1001, 1002, 967, 999, 998, 997, 996, 995, 1029, 1040, 968, 969, 1069, 822, 722, 296, 295, 294, 293, 169, 161, 160, 163, 209, 254, 3, 5, 0]

# 샘플 분석 –Genetic Algorithm data3

Execution Time : 261.21137380599976

Cost : 6917.188075125465




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, 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, 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, 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, 742, 686, 749, 769, 770, 771, 772, 773, 776, 817, 818, 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, 615, 616, 617, 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, 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, 331, 310, 311, 332, 354, 355, 356, 357, 392, 393, 405, 427, 428, 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,

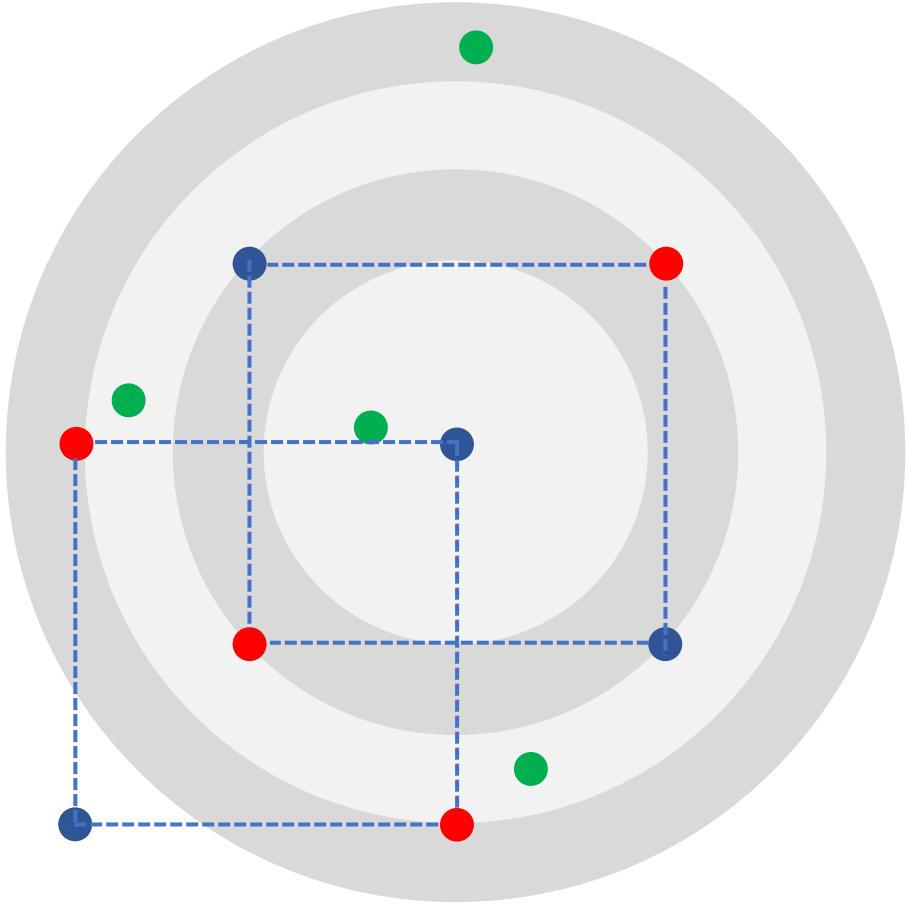
# 샘플 분석 –Genetic Algorithm data3

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, 24, 69, 79, 78, 77, 76, 144, 155, 158, 164, 154, 163, 174, 191, 220, 278, 277, 276, 275, 274, 273, 272, 214, 216, 217, 218, 219, 189, 190, 213, 212, 211, 210, 209, 208, 207, 206, 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, 521, 522, 552, 566, 523, 509, 493, 494, 510, 524, 525, 511, 495, 471, 472, 426, 425, 424, 423, 422, 421, 420, 469, 468, 419, 418, 416, 415, 414, 413, 389, 390, 391, 473, 526, 553, 549, 470, 551, 774, 819, 779, 781, 782, 783, 784, 785, 786, 787, 820, 821, 822, 823, 791, 792, 793, 794, 795, 796, 797, 824, 825, 798, 799, 826, 827, 828, 838, 845, 853, 864, 863, 852, 869, 862, 851, 844, 861, 860, 850, 843, 871, 879, 878, 877, 859, 849, 842, 841, 848, 858, 857, 856, 847, 840, 788, 789, 790, 753, 649, 650, 651, 601, 602, 652, 653, 654, 603, 568, 533, 534, 480, 479, 478, 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, 530, 554, 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, 962, 971, 972, 973, 1036, 998, 1207, 1249, 1372, 1402, 1371, 1342, 1318, 1317, 1341, 1369, 1368, 1340, 1316, 1339, 1367, 1366, 1338, 1365, 1315, 1364, 1395, 1396, 1397, 1289, 1288, 1287, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1248, 1292, 1291, 1290, 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, 1309, 1332, 1358, 1279, 1226, 1227, 1228, 1280, 1281, 1225, 1224, 1278, 1277, 1276, 1223, 1222, 1221, 1220, 1219, 1218, 1217, 1216, 1215, 1214, 1213, 1212, 1211, 1210, 1209, 1270, 1269, 1268, 1302, 1271, 1327, 1350, 1384, 1383, 1349, 1326, 1351, 1303, 1304, 1329, 1352, 1353, 1330, 1305, 1306, 1331, 1354, 1355, 1307, 1356, 1357, 1391, 1412, 1400, 1390, 1389, 1411, 1410, 1409, 1408, 1407, 1406, 1456, 1485, 1506, 1516, 1517, 1486, 1488, 1507, 1518, 1519, 1489, 1520, 1544, 1545, 1543, 1542, 1458, 1413, 1414, 1415, 1416, 1417, 1459, 1460, 1418, 1419, 1420, 1421, 1422, 1423, 1424, 1425, 1426, 1427, 1428, 1429, 1462, 1463, 1495, 1510, 1494, 1493, 1509, 1525, 1547, 1524, 1492, 1491, 1523, 1521, 1508, 1490, 1461, 1546, 1548, 1549, 1526, 1496, 1511, 1464, 1430, 1431, 1465, 1432, 1433, 1435, 1436, 1466, 1467, 1483, 1468, 1469, 1555, 1554, 1553, 1552, 1538, 1551, 1528, 1497, 1527, 1550, 1581, 1582, 1583, 1584, 1585, 1580, 1579, 1578, 1576, 1575, 1574, 1573, 1572, 1571, 1570, 1598, 1597, 1596, 1594, 1593, 1592, 1591, 1590, 1589, 1588, 1587, 1586, 1577, 1595, 1564, 1541, 1522, 1487, 1505, 1503, 1514, 1502, 1482, 1457, 1434, 1437, 1470, 1471, 1472, 1438, 1439, 1440, 1441, 1442, 1443, 1444, 1445, 1446, 1447, 1448, 1449, 1474, 1475, 1476, 1477, 1478, 1479, 1484, 1480, 1481, 1450, 1451, 1452, 1453, 1454, 1504, 1536, 1567, 1568, 1537, 1569, 1515, 1455, 1405, 1387, 1272, 1273, 1274, 1189, 1154, 1155, 1130, 1103, 1104, 1131, 1156, 1105, 1132, 1106, 1133, 1107, 1071, 1070, 1069, 1009, 1008, 1007, 1006, 1068, 1067, 1005, 1004, 1003, 1002, 1001, 1000, 999, 1064, 1063, 1062, 1061, 1100, 1099, 1059, 1058, 1057, 1056, 1055, 1054, 1053, 1052, 1096, 1097, 1098, 1126, 1149, 1183, 1182, 1148, 1125, 1124, 1147, 1181, 1095, 1094, 1093, 1051, 1050, 1049, 1048, 1047, 1089, 1090, 1091, 1123, 1146, 1178, 1176, 1145, 1122, 1188, 1196, 1197, 1175, 1121, 1120, 1144, 1174, 1173, 1143, 1119, 1118, 1142, 1172, 1086, 1038, 1039, 1040, 1041, 1042, 1043, 1044, 1045, 1046, 1088, 1087, 1037, 1085, 1084, 1083, 1022, 1060, 1092, 1177, 1198, 1204, 1206, 1169, 1171, 1250, 1251, 1252, 1253, 1254, 1255, 1256, 1257, 1258, 1259, 1260, 1261, 1262, 1263, 1264, 1265, 1297, 1296, 1295, 1294, 1293, 1321, 1344, 1375, 1374, 1343, 1320, 1319, 1373, 1398, 1376, 1345, 1322, 1323, 1346, 1377, 1378, 1347, 1324, 1379, 1404, 1380, 1381, 1298, 1299, 1300, 1348, 1382, 1267, 1203, 1199, 1200, 1205, 1185, 1150, 1127, 1128, 1151, 1186, 1152, 1129, 1102, 1065, 1066, 1101, 997, 996, 978, 995, 994, 993, 992, 991, 990, 989, 988, 987, 986, 956, 977, 929, 882, 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, 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, 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, 1153, 1201, 1184, 1180, 1179, 1208, 1266, 1540, 1561, 1562, 1563, 1565, 1566, 1539, 1535, 1534, 1513, 1501, 1500, 1533, 1532, 1512, 1499, 1498, 1531, 1558, 1557, 1556, 1529, 1530, 1559, 1560, 1473, 1370, 1314, 1334, 1308, 1328, 1325, 1301, 1275, 1286, 1394, 1388, 1399, 1386, 733, 383, 375, 300, 743, 744, 304, 358, 369, 604, 732, 777, 846, 855, 866, 865, 854, 874, 875, 873, 872, 942, 950, 955, 961, 970, 969, 968, 1032, 1033, 1034, 1031, 1030, 1029, 1028, 1027, 1026, 1025, 1024, 1023, 1077, 1076, 1075, 1020, 1021, 1078, 1079, 1080, 1081, 1116, 1141, 1166, 1165, 1140, 1115, 1114, 1139, 1164, 1163, 1138, 1113, 1162, 1161, 1137, 1112, 1187, 1160, 1136, 1111, 1110, 1135, 1159, 1158, 1134, 1109, 1108, 1157, 1192, 1191, 1190, 1072, 1073, 1074, 1019, 1193, 1285, 1313, 1337, 1363, 1401, 1393, 1392, 1167, 1117, 1168, 1195, 1194, 1202, 1170, 1082, 1035, 1403, 0]

# 느낀점

- 생명공학 분야의 개념을 가져와서 알고리즘화 시킨 점이 인상깊다.
- 유전적 내용을 모르고서도 생각할 수 있었겠지만 유전에 대한 학문이 이미 존재했기에 이런쪽으로 생각하는 것이 더 쉽지 않았을까 생각된다. (인공 싱경망도 한가지 예시가 될 것 같다)
- 하지만 좋은 부모에서 좋은 자식이 태어날 것이라는 가정은 문제에 따라 하기 힘들 수도 있을것 같다.  -> 과녁판 예시

# 느낀점 - 과녁판



- 부모 경로
- 자식 경로
  - Only crossover
  - No mutation
- Mutation (Child1)

정말 단순한 예시이지만 (설명을 위해 2차원 좌표로 가정, 차원을 늘려도 동일)
다음과 같이 좌표로 표현이 되며 crossover이 일어날 경우 점수가 높은 두 parent를 선택하는 것보다 점수가 낮은 두 parent를 선택하는 경우가 더 뛰어난 Child가 생긴다

SA처럼 Bad move를 허용하면 더 좋은 결과가 나올 수도 있지 않을까?

# 과녁판 예시로부터 새롭게 생각한점

- Crossover할때 좌표의 교환이 아닌 두 부모의 평균값으로 할 경우 뛰어난 부모를 선택했을 때 가장 훌륭한 child를 얻을 수 있게된다.

- 전 페이지에서 말한 방법이 bad moves를 허용해서 genetic algorithm을 진행하는 아이디어였다면 위 방법은 crossover 방식에 변화를 주어서 알고리즘을 개선시키자는 아이디어이다.

- 각 문제별로 알맞은 crossover 방식이 있을테니 한가지 방법으로 시도하지말고 최적의 crossover 방식을 찾는것이 중요할거같다.

# Improvement

- Mutation부분이 상대적으로 허술하다고 느꼈으며 더 효율적으로 바꿀 수 있을 것 같았다.

- 생명공학적 관점에서도 보면 돌연변이는 항상 좋은 방향으로 일어나는 것이 아니다.
  다양한 방향으로 일어나며 적자 생존의 원리로 좋지 않은 방향으로 돌연변이가 일어난 생물들이 도태 되는 것이다.

- 어떤 방향으로 돌연변이가 일어나면 생존할 수 있는지 알고있고 동시에 어떻게 바뀔지 선택권이 있었다면 수많은 생명체들이 도태되었을까? ✗

# 유전 알고리즘에서는 어떨까?

일단 우리는 원하는 방향으로 돌연변이를 일으킬 수 있다는 점에서 자연적인 돌연변이보다 우위에 있다.
->Random Mutation은 이러한 우위를 버리고 자연과 똑같아지는 방법이므로 비효율적이라고 할 수 있다.

어떤 방향의 돌연변이가 좋은가?
-> 알 수 없다! 그러므로 완벽한 정답을 얻는 것은 불가능하다.
-> 하지만, 언제나 안 좋은 선택을 하는 경우에는 올바른 정답으로 도달할 수 없다는 사실은 안다!
-> Random한 Moves를 도입하되  bad moves일 경우에는 정해진 확률을 넘어야만 적용되도록 하자!

❖방법 1 : Mutation을 확률적으로 Bad moves를 허용
❖방법 2 : Mutation이 랜덤으로 일어날 때 성능 개선이 일어날 때만 mutation을 허용하자
❖방법 2 : Mutation의 횟수를 증가 (MUTATION_RATE 변수 도입)

# Mutation 변화

```
def mutation(path, path_map):
    # Swap mutation
    path_size = len(path) - 1
    sel_idx = np.random.randint(1, path_size, size=2)
    child = path.copy()
    child[sel_idx[0]], child[sel_idx[1]] = child[sel_idx[1]], child[sel_idx[0]]
    cost1 = path_cost(path_map, path).sum()
    cost2 = path_cost(path_map, child).sum()
    rate = np.random.rand(1)

    if cost1 < cost2 :
        if ACCEPT_RATIO > rate :
            return child
        else :
            return path
    else :
        if ACCEPT_RATIO > rate:
            return path
        else :
            return child
```

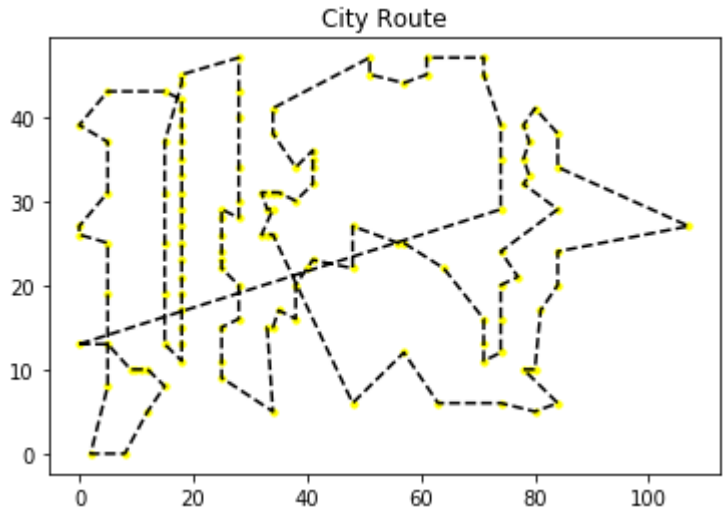
# Mutation iteration 변화

- for j in range(MUTATION_ITER):
- index = j+3
- child3 = mutation(path_pool[indices[0], :],path_map)
- path_pool[-index, :], pool_cost[-index] = child3, path_cost(path_map, child3).sum()

in "ga search function"

# Genetic Algorithm improve data1

Execution time : 70.71746969223022



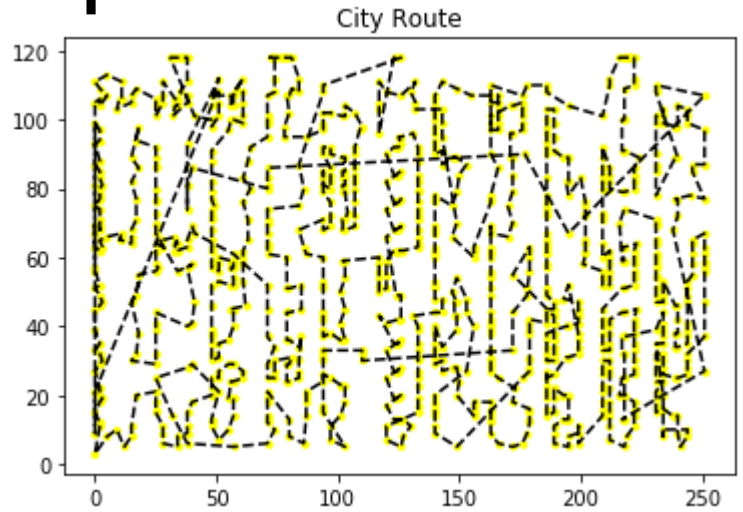

Cost : 667.9022395364784

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

# Genetic Algorithm improve data2

Execution time : 493.67140913009644

Cost : 4666.293226009454




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, 149, 144, 151, 152, 147, 146, 145, 138, 132, 128, 126, 170, 173, 204, 206, 207, 208, 175, 227, 226, 236, 237, 254, 250, 253, 252, 251, 263, 235, 225, 224, 203, 202, 201, 200, 199, 205, 198, 197, 196, 195, 194, 193, 192, 191, 190, 216, 217, 218, 234, 248, 247, 233, 246, 245, 232, 215, 189, 188, 187, 186, 185, 184, 183, 182, 213, 214, 223, 242, 243, 231, 264, 257, 258, 259, 260, 265, 266, 261, 268, 262, 267, 269, 297, 298, 270, 271, 272, 302, 303, 304, 300, 299, 309, 310, 311, 312, 316, 325, 334, 337, 336, 333, 324, 315, 323, 314, 313, 356, 386, 387, 388, 357, 389, 408, 419, 420, 436, 450, 446, 445, 444, 443, 442, 441, 440, 439, 438, 437, 428, 412, 413, 429, 435, 430, 414, 415, 431, 432, 416, 417, 433, 434, 418, 401, 402, 385, 384, 400, 399, 398, 397, 381, 382, 383, 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, 427, 411, 460, 459, 458, 457, 456, 455, 468, 469, 470, 481, 491, 503, 518, 525, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 530, 523, 508, 522, 507, 495, 485, 475, 484, 494, 506, 521, 474, 483, 493, 520, 505, 473, 482, 492, 504, 519, 471, 490, 502, 516, 515, 501, 467, 454, 480, 489, 500, 514, 466, 479, 488, 499, 513, 465, 478, 487, 498, 512, 464, 477, 486, 497, 511, 524, 528, 526, 517, 472, 463, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 529, 580, 606, 607, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 615, 630, 633, 637, 631, 620, 616, 608, 609, 596, 597, 598, 599, 600, 561, 562, 563, 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, 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, 642, 641, 640, 639, 622, 632, 623, 617, 612, 603, 604, 573, 574, 575, 576, 577, 578, 579, 605, 624, 625, 618, 619, 626, 613, 628, 636, 635, 643, 634,

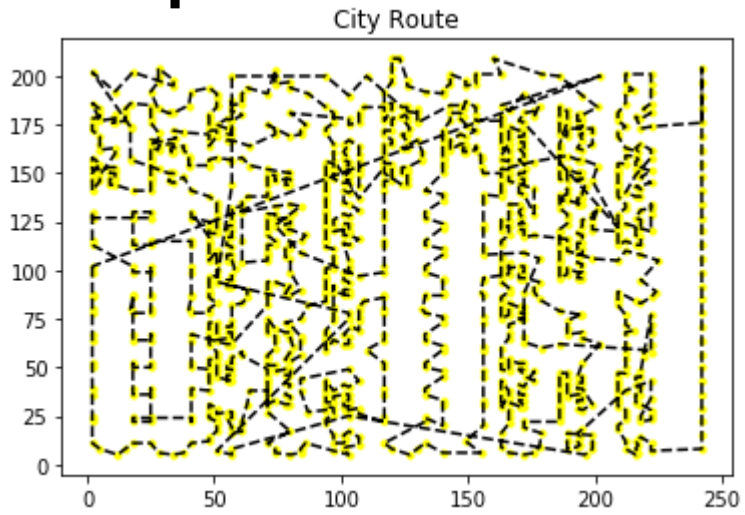
# Genetic Algorithm improve data2

572, 571, 570, 569, 568, 567, 566, 595, 627, 718, 731, 732, 733, 734, 735, 736, 737, 738, 759, 760, 761, 798, 799, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 743, 744, 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, 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, 745, 746, 723, 717, 650, 685, 694, 683, 682, 681, 646, 645, 644, 614, 629, 610, 611, 601, 531, 532, 527, 533, 509, 462, 453, 452, 451, 461, 476, 496, 510, 359, 358, 344, 350, 343, 292, 291, 290, 289, 288, 287, 286, 322, 321, 331, 347, 346, 330, 320, 319, 329, 341, 345, 340, 339, 338, 327, 317, 318, 328, 335, 307, 306, 305, 280, 281, 308, 282, 283, 284, 249, 172, 168, 159, 158, 141, 133, 134, 142, 135, 124, 123, 105, 104, 103, 117, 102, 86, 81, 71, 85, 80, 70, 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, 35, 12, 13, 14, 38, 37, 39, 40, 15, 41, 42, 43, 53, 44, 45, 17, 46, 19, 47, 48, 20, 16, 11, 10, 34, 9, 33, 51, 32, 8, 7, 31, 6, 30, 50, 29, 4, 28, 27, 49, 26, 2, 25, 24, 5, 57, 58, 66, 75, 69, 79, 95, 94, 93, 92, 120, 125, 122, 139, 143, 162, 150, 153, 164, 179, 180, 181, 211, 212, 222, 230, 241, 256, 255, 240, 229, 221, 228, 239, 238, 220, 219, 176, 177, 178, 210, 165, 154, 96, 129, 157, 244, 285, 301, 273, 274, 275, 276, 277, 278, 279, 326, 332, 348, 351, 352, 353, 354, 363, 364, 391, 404, 409, 422, 421, 403, 390, 394, 425, 360, 361, 362, 365, 366, 367, 368, 449, 448, 447, 704, 705, 724, 725, 739, 740, 741, 742, 707, 797, 796, 795, 794, 793, 792, 791, 754, 755, 756, 757, 758, 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, 944, 945, 923, 909, 904, 910, 924, 946, 947, 948, 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, 958, 959, 965, 931, 916, 930, 915, 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, 1065, 1066, 1079, 1078, 1077, 1076, 1075, 1074, 1073, 1072, 1071, 1050, 1049, 1048, 1047, 1033, 1024, 1006, 1007, 1008, 1009, 978, 977, 976, 975, 974, 1005, 973, 972, 971, 970, 1003, 1021, 1023, 1032, 1041, 1043, 1059, 1044, 1000, 1019, 1004, 979, 1010, 1011, 1012, 1013, 1014, 980, 926, 912, 911, 925, 922, 908, 1070, 1022, 1038, 1039, 1028, 1061, 1080, 1067, 1068, 1081, 1082, 1060, 1045, 1046, 1031, 1042, 1030, 1020, 1001, 1002, 967, 999, 998, 997, 996, 995, 1029, 1040, 968, 969, 1069, 822, 722, 296, 295, 294, 293, 169, 161, 160, 163, 209, 174, 3, 18, 0]

# Genetic Algorithm improve data3

Execution Time : 769.8247892856598

Cost : 6921.892128526468




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, 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, 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, 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, 742, 686, 749, 769, 770, 771, 772, 773, 776, 817, 818, 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, 615, 616, 617, 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, 443, 444, 445, 446, 447, 448, 449, 402, 403, 377, 376, 342, 321, 320,

# Genetic Algorithm improve data3

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, 331, 310, 311, 332, 354, 355, 356, 357, 392, 393, 405, 427, 428, 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, 63, 57, 53, 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, 68, 67, 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, 276, 275, 274, 273, 272, 214, 216, 217, 218, 219, 189, 190, 213, 212, 211, 210, 209, 208, 207, 206, 205, 271, 270, 269, 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, 521, 522, 552, 566, 523, 509, 493, 494, 510, 524, 525, 511, 495, 471, 472, 426, 425, 424, 423, 422, 421, 420, 469, 468, 419, 418, 416, 415, 414, 413, 389, 390, 391, 473, 526, 553, 549, 470, 551, 774, 819, 779, 781, 782, 783, 784, 785, 786, 787, 820, 821, 822, 823, 791, 792, 793, 794, 795, 796, 797, 824, 825, 798, 799, 826, 827, 828, 838, 845, 853, 864, 863, 852, 869, 862, 851, 844, 861, 860, 850, 843, 871, 879, 878, 877, 859, 849, 842, 841, 848, 858, 857, 856, 847, 840, 788, 789, 790, 753, 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, 530, 554, 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, 962, 971, 972,

# Genetic Algorithm improve data3

1973, 1036, 998, 1207, 1249, 1372, 1402, 1371, 1342, 1318, 1317, 1341, 1369, 1368, 1340, 1316, 1339, 1367, 1366, 1338, 1365, 1315, 1364, 1395, 1396, 1397, 1289, 1288, 1287, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1248, 1292, 1291, 1290, 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, 1309, 1332, 1358, 1279, 1226, 1227, 1228, 1280, 1281, 1225, 1224, 1278, 1277, 1276, 1223, 1222, 1221, 1220, 1219, 1218, 1217, 1216, 1215, 1214, 1213, 1212, 1211, 1210, 1209, 1270, 1269, 1268, 1302, 1271, 1327, 1350, 1384, 1383, 1349, 1326, 1351, 1303, 1304, 1329, 1352, 1353, 1330, 1305, 1306, 1331, 1354, 1355, 1307, 1356, 1357, 1391, 1392, 1400, 1390, 1389, 1411, 1410, 1409, 1408, 1407, 1406, 1456, 1485, 1506, 1516, 1517, 1486, 1488, 1507, 1518, 1519, 1489, 1520, 1544, 1545, 1543, 1542, 1458, 1413, 1414, 1415, 1416, 1417, 1459, 1460, 1418, 1419, 1420, 1421, 1422, 1423, 1424, 1425, 1426, 1427, 1428, 1429, 1462, 1463, 1495, 1510, 1494, 1493, 1509, 1525, 1547, 1524, 1546, 1491, 1523, 1521, 1508, 1490, 1461, 1492, 1548, 1549, 1526, 1496, 1511, 1464, 1430, 1431, 1465, 1432, 1433, 1435, 1436, 1466, 1467, 1483, 1468, 1469, 1555, 1554, 1553, 1552, 1538, 1551, 1528, 1497, 1527, 1550, 1581, 1582, 1583, 1584, 1585, 1580, 1579, 1578, 1576, 1575, 1574, 1573, 1572, 1571, 1570, 1598, 1597, 1596, 1594, 1593, 1592, 1591, 1590, 1589, 1588, 1587, 1586, 1577, 1595, 1564, 1541, 1522, 1487, 1505, 1503, 1514, 1502, 1482, 1457, 1434, 1437, 1470, 1471, 1472, 1438, 1439, 1440, 1441, 1442, 1443, 1444, 1445, 1446, 1447, 1448, 1449, 1474, 1475, 1476, 1477, 1478, 1479, 1484, 1480, 1481, 1450, 1451, 1452, 1453, 1454, 1504, 1536, 1567, 1568, 1537, 1569, 1515, 1455, 1405, 1387, 1272, 1273, 1274, 1189, 1154, 1155, 1130, 1103, 1104, 1131, 1156, 1105, 1132, 1106, 1133, 1107, 1071, 1070, 1069, 1009, 1008, 1007, 1006, 1068, 1067, 1005, 1004, 1003, 1002, 1001, 1000, 999, 1064, 1063, 1062, 1061, 1100, 1099, 1059, 1058, 1057, 1056, 1055, 1054, 1053, 1052, 1096, 1097, 1098, 1126, 1149, 1183, 1182, 1148, 1125, 1124, 1147, 1181, 1095, 1094, 1093, 1051, 1050, 1049, 1048, 1047, 1089, 1090, 1091, 1123, 1146, 1178, 1176, 1145, 1122, 1188, 1196, 1197, 1175, 1121, 1120, 1144, 1174, 1173, 1143, 1119, 1172, 1142, 1118, 1086, 1038, 1039, 1040, 1041, 1042, 1043, 1044, 1045, 1046, 1088, 1087, 1037, 1085, 1084, 1083, 1022, 1060, 1092, 1177, 1198, 1204, 1206, 1169, 1171, 1250, 1251, 1252, 1253, 1254, 1255, 1256, 1257, 1258, 1259, 1260, 1261, 1262, 1263, 1264, 1265, 1297, 1296, 1295, 1294, 1293, 1321, 1344, 1375, 1374, 1343, 1320, 1319, 1373, 1398, 1376, 1345, 1322, 1323, 1346, 1377, 1378, 1347, 1324, 1379, 1404, 1380, 1381, 1298, 1299, 1300, 1348, 1382, 1267, 1203, 1199, 1200, 1205, 1185, 1150, 1127, 1128, 1151, 1186, 1152, 1129, 1102, 1065, 1066, 1101, 997, 996, 978, 995, 994, 993, 992, 991, 990, 989, 988, 987, 986, 956, 977, 929, 882, 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, 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, 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, 1153, 1201, 1184, 1180, 1179, 1208, 1266, 1540, 1561, 1562, 1563, 1565, 1566, 1539, 1535, 1534, 1513, 1501, 1500, 1533, 1532, 1512, 1499, 1498, 1531, 1558, 1557, 1556, 1529, 1530, 1559, 1560, 1473, 1370, 1314, 1334, 1308, 1328, 1325, 1301, 1275, 1286, 1394, 1388, 1399, 1386, 733, 383, 375, 300, 743, 744, 304, 358, 369, 604, 732, 777, 846, 855, 866, 865, 854, 874, 875, 873, 872, 942, 950, 955, 961, 970, 969, 968, 1032, 1033, 1034, 1031, 1030, 1029, 1028, 1027, 1026, 1025, 1024, 1023, 1077, 1076, 1075, 1020, 1021, 1078, 1079, 1080, 1081, 1116, 1141, 1166, 1165, 1140, 1115, 1114, 1139, 1164, 1163, 1138, 1113, 1162, 1161, 1137, 1112, 1187, 1160, 1136, 1111, 1110, 1135, 1159, 1158, 1134, 1109, 1108, 1157, 1190, 1191, 1192, 1072, 1073, 1074, 1019, 1193, 1285, 1313, 1337, 1363, 1401, 1393, 1412, 1167, 1117, 1168, 1195, 1194, 1202, 1170, 1082, 1035, 1403, 0]

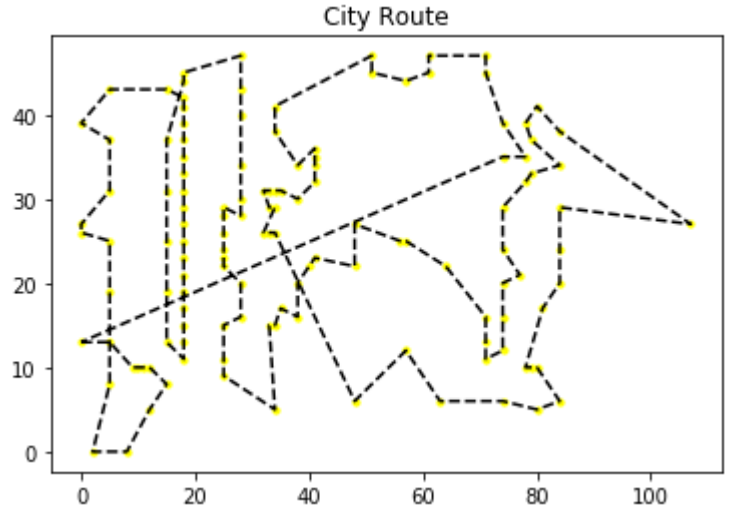
# Without Bad moves

- Bad moves를 허용하지않고 랜덤으로 mutation이 일어났을때 cost를 계산하여 개선이 있었을때만 mutation을 받아들이도록 변경!

- 기존의 코드에서 ACCEPT_RATE를 극도로 낮추어 (0.001) bad moves를 확률상 거의 허락하지 않도록 수정

# Genetic Algorithm improve data1

Execution time : 60.614914894104004

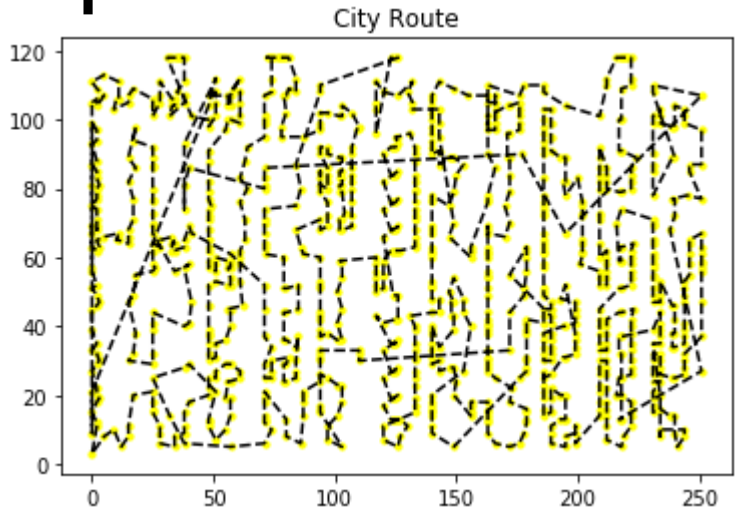



Cost : 668.9553385108235

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

# Genetic Algorithm improve data2

Execution time : 407.54419231414795




Cost : 4643.689009190809

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, 149, 144, 151, 152, 147, 146, 145, 138, 132, 128, 126, 170, 173, 204, 206, 207, 208, 175, 227, 226, 236, 237, 254, 250, 253, 252, 251, 263, 235, 225, 224, 203, 202, 201, 200, 199, 205, 198, 197, 196, 195, 194, 193, 192, 191, 190, 216, 217, 218, 234, 248, 247, 233, 246, 245, 232, 215, 189, 188, 187, 186, 185, 184, 183, 182, 213, 214, 223, 242, 243, 231, 264, 257, 258, 259, 260, 265, 266, 261, 268, 262, 267, 269, 297, 298, 270, 271, 272, 302, 303, 304, 300, 299, 309, 310, 311, 312, 316, 325, 334, 337, 336, 333, 324, 315, 323, 314, 313, 356, 386, 387, 388, 357, 389, 408, 419, 420, 436, 450, 446, 445, 444, 443, 442, 441, 440, 439, 438, 437, 428, 412, 413, 429, 435, 430, 414, 415, 431, 432, 416, 417, 433, 434, 418, 401, 402, 385, 384, 400, 399, 398, 397, 381, 382, 383, 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, 427, 411, 460, 459, 458, 457, 456, 455, 468, 469, 470, 481, 491, 503, 518, 525, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 530, 523, 508, 522, 507, 495, 485, 475, 484, 494, 506, 521, 474, 483, 493, 520, 505, 473, 482, 492, 504, 519, 471, 490, 502, 516, 515, 501, 467, 454, 480, 489, 500, 514, 466, 479, 488, 499, 513, 465, 478, 487, 498, 512, 464, 477, 486, 497, 511, 524, 528, 526, 517, 472, 463, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 529, 580, 606, 607, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 615, 630, 633, 637, 631, 620, 616, 608, 609, 596, 597, 598, 599, 600, 561, 562, 563, 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, 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, 642, 641, 640, 639, 622, 632, 623, 617, 612, 603, 604, 573, 574, 575, 576, 577, 578, 579, 605, 624, 625, 618, 619, 626, 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, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 743, 744, 785, 804, 803, 802, 808, 814, 826, 825, 813, 823, 822, 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, 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, 745, 746, 723, 717, 650, 685, 694, 683, 682, 681, 646, 645, 644, 614, 629, 610,

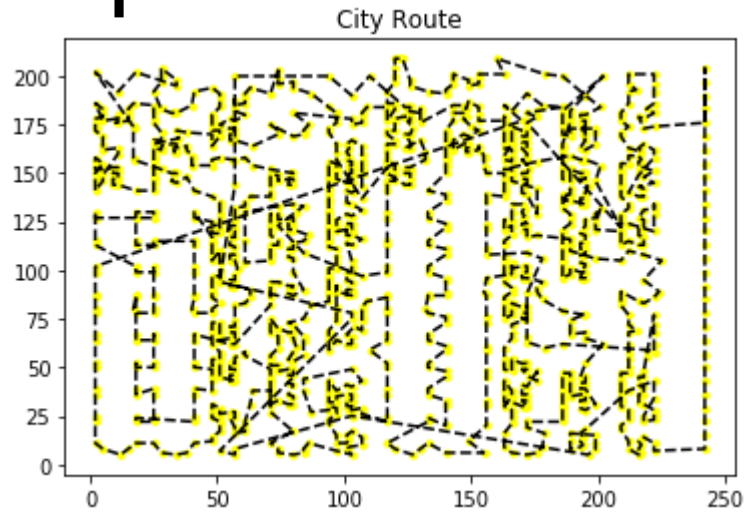
# Genetic Algorithm improve data2

611, 601, 531, 532, 527, 533, 509, 462, 453, 452, 451, 461, 510, 496, 476, 359, 358, 344, 350, 343, 292, 291, 290, 289, 288, 287, 286, 322, 321, 331, 347, 346, 330, 320, 319, 329, 341, 345, 340, 339, 338, 327, 317, 318, 328, 335, 307, 306, 305, 280, 281, 308, 282, 283, 284, 249, 172, 168, 159, 158, 141, 133, 134, 142, 135, 124, 123, 105, 104, 103, 117, 102, 86, 81, 71, 85, 80, 70, 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, 35, 12, 13, 14, 38, 37, 39, 40, 15, 41, 42, 43, 53, 44, 45, 17, 46, 19, 47, 48, 20, 16, 11, 10, 34, 9, 33, 51, 32, 8, 7, 31, 6, 30, 50, 29, 4, 28, 27, 49, 26, 2, 25, 24, 57, 5, 58, 66, 75, 69, 79, 95, 94, 93, 92, 120, 125, 122, 139, 143, 162, 150, 153, 164, 179, 180, 210, 211, 212, 222, 230, 241, 256, 255, 240, 229, 221, 228, 239, 238, 220, 219, 176, 177, 178, 181, 165, 154, 96, 129, 157, 244, 285, 301, 273, 274, 275, 276, 277, 278, 279, 326, 332, 348, 351, 352, 353, 354, 363, 364, 391, 404, 409, 422, 421, 403, 425, 394, 390, 360, 361, 362, 365, 366, 367, 368, 449, 448, 447, 704, 705, 724, 725, 739, 740, 741, 742, 707, 797, 796, 795, 794, 793, 792, 791, 754, 755, 756, 757, 758, 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, 944, 945, 923, 909, 904, 910, 924, 946, 947, 948, 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, 958, 959, 965, 931, 916, 930, 915, 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, 1065, 1066, 1079, 1078, 1077, 1076, 1075, 1074, 1073, 1072, 1071, 1050, 1049, 1048, 1047, 1033, 1024, 1006, 1007, 1008, 1009, 978, 977, 976, 975, 974, 1005, 973, 972, 971, 970, 1003, 1021, 1023, 1032, 1041, 1043, 1059, 1044, 1000, 1019, 1004, 979, 1010, 1011, 1012, 1013, 1014, 980, 926, 912, 911, 925, 922, 908, 1070, 1022, 1038, 1039, 1028, 1061, 1080, 1067, 1068, 1081, 1082, 1060, 1045, 1046, 1031, 1042, 1030, 1020, 1001, 1002, 967, 999, 998, 997, 996, 995, 1029, 1040, 968, 969, 1069, 838, 722, 296, 295, 294, 293, 160, 161, 169, 163, 209, 174, 3, 18, 0]

# Genetic Algorithm improve data3

Execution Time : 756.2946116924286

Cost : 6900.082012725975




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, 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, 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, 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, 742, 686, 749, 769, 770, 771, 772, 773, 776, 817, 818, 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, 615, 616, 617, 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, 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, 331, 310, 311, 332, 354, 355, 356, 357, 392, 393, 405, 427, 428, 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, 63, 57, 53, 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, 68, 67, 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, 276, 275, 274, 273, 272, 214, 216, 217, 218, 219, 189, 190, 213, 212, 211, 210, 209, 208, 207, 206, 205, 271, 270, 269, 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, 134, 133, 132, 131, 90, 91, 193, 194, 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, 521, 522, 552, 566, 523, 509, 493, 494, 510, 524, 525, 511, 495, 471, 472, 426, 425, 424, 423, 422, 421, 420, 469, 468, 419, 418, 416, 415, 414, 413, 389, 390, 391, 473, 526, 553, 549, 470, 551, 774, 819, 779, 781, 782, 783, 784, 785, 786, 787, 820, 821, 822, 823, 791, 792, 793, 794, 795, 796, 797, 824, 825, 798, 799, 826, 827, 828, 838, 845, 853, 864, 863, 852, 869, 862, 851, 844, 861, 860, 850, 843, 871, 879, 878, 877, 859, 849, 842, 841, 848, 858, 857, 856, 847, 840, 788, 789, 790, 753, 649, 650, 651, 601, 602, 652, 653, 654, 603, 568, 533, 534

# Genetic Algorithm improve data3

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, 530, 554, 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, 962, 971, 972, 973, 1036, 998, 1207, 1249, 1372, 1402, 1371, 1342, 1318, 1317, 1341, 1369, 1368, 1340, 1316, 1339, 1367, 1366, 1338, 1365, 1315, 1364, 1395, 1396, 1397, 1289, 1288, 1287, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1403, 1292, 1291, 1290, 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, 1309, 1332, 1358, 1279, 1226, 1227, 1228, 1280, 1281, 1225, 1224, 1278, 1277, 1276, 1223, 1222, 1221, 1220, 1219, 1218, 1217, 1216, 1215, 1214, 1213, 1212, 1211, 1210, 1209, 1270, 1269, 1268, 1302, 1271, 1327, 1350, 1384, 1383, 1349, 1326, 1351, 1303, 1304, 1329, 1352, 1353, 1330, 1305, 1306, 1331, 1354, 1355, 1307, 1356, 1357, 1391, 1392, 1400, 1390, 1389, 1411, 1410, 1409, 1408, 1407, 1406, 1456, 1485, 1506, 1516, 1517, 1486, 1488, 1507, 1518, 1519, 1489, 1520, 1544, 1545, 1543, 1542, 1458, 1413, 1414, 1415, 1416, 1417, 1459, 1460, 1418, 1419, 1420, 1421, 1422, 1423, 1424, 1425, 1426, 1427, 1428, 1429, 1462, 1463, 1495, 1510, 1494, 1493, 1509, 1525, 1547, 1524, 1546, 1491, 1523, 1521, 1508, 1490, 1461, 1492, 1548, 1549, 1526, 1496, 1511, 1464, 1430, 1431, 1465, 1432, 1433, 1435, 1436, 1466, 1467, 1483, 1468, 1469, 1555, 1554, 1553, 1552, 1538, 1551, 1528, 1497, 1527, 1550, 1581, 1582, 1583, 1584, 1585, 1580, 1579, 1578, 1576, 1575, 1574, 1573, 1572, 1571, 1570, 1598, 1597, 1596, 1594, 1593, 1592, 1591, 1590, 1589, 1588, 1587, 1586, 1577, 1595, 1564, 1541, 1522, 1487, 1505, 1503, 1514, 1502, 1482, 1457, 1434, 1437, 1470, 1471, 1472, 1438, 1439, 1440, 1441, 1442, 1443, 1444, 1445, 1446, 1447, 1448, 1449, 1474, 1475, 1476, 1477, 1478, 1479, 1484, 1480, 1481, 1450, 1451, 1452, 1453, 1454, 1504, 1536, 1567, 1568, 1537, 1569, 1515, 1455, 1405, 1387, 1272, 1273, 1274, 1189, 1154, 1155, 1130, 1103, 1104, 1131, 1156, 1105, 1132, 1106, 1133, 1107, 1071, 1070, 1069, 1009, 1008, 1007, 1006, 1068, 1067, 1005, 1004, 1003, 1002, 1001, 1000, 999, 1064, 1063, 1062, 1061, 1100, 1099, 1059, 1058, 1057, 1056, 1055, 1054, 1053, 1052, 1096, 1097, 1098, 1126, 1149, 1183, 1182, 1148, 1125, 1124, 1147, 1181, 1095, 1094, 1093, 1051, 1050, 1049, 1048, 1047, 1089, 1090, 1091, 1123, 1146, 1178, 1176, 1145, 1122, 1188, 1196, 1197, 1175, 1121, 1120, 1144, 1174, 1173, 1143, 1119, 1172, 1142, 1118, 1086, 1038, 1039, 1040, 1041, 1042, 1043, 1044, 1045, 1046, 1088, 1087, 1037, 1085, 1084, 1083, 1022, 1060, 1092, 1177, 1198, 1204, 1206, 1169, 1171, 1250, 1251, 1252, 1253, 1254, 1255, 1256, 1257, 1258, 1259, 1260, 1261, 1262, 1263, 1264, 1265, 1297, 1296, 1295, 1294, 1293, 1321, 1344, 1375, 1374, 1343, 1320, 1319, 1373, 1398, 1376, 1345, 1322, 1323, 1346, 1377, 1378, 1347, 1324, 1379, 1404, 1380, 1381, 1298, 1299, 1300, 1348, 1382, 1267, 1203, 1199, 1200, 1205, 1185, 1150, 1127, 1128, 1151, 1186, 1152, 1129, 1102, 1065, 1066, 1101, 997, 996, 978, 995, 994, 993, 992, 991, 990, 989, 988, 987, 986, 956, 977, 929, 882, 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, 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, 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, 1153, 1201, 1184, 1180, 1179, 1208, 1266, 1540, 1561, 1562, 1563, 1565, 1566, 1539, 1535, 1534, 1513, 1501, 1500, 1533, 1532, 1512, 1499, 1498, 1531, 1558, 1557, 1556, 1529, 1530, 1559, 1560, 1473, 1370, 1314, 1334, 1308, 1328, 1325, 1301, 1275, 1286, 1394, 1388, 1399, 1386, 733, 383, 375, 300, 743, 744, 304, 358, 369, 604, 732, 777, 846, 855, 866, 865, 854, 874, 875, 873, 872, 942, 950, 955, 961, 970, 969, 968, 1032, 1033, 1034, 1031, 1030, 1029, 1028, 1027, 1026, 1025, 1024, 1023, 1077, 1076, 1075, 1020, 1021, 1078, 1079, 1080, 1081, 1116, 1141, 1166, 1165, 1140, 1115, 1114, 1139, 1164, 1163, 1138, 1113, 1162, 1161, 1137, 1112, 1187, 1160, 1136, 1111, 1110, 1135, 1159, 1158, 1134, 1109, 1108, 1157, 1190, 1191, 1192, 1072, 1073, 1074, 1019, 1193, 1285, 1313, 1337, 1363, 1401, 1393, 1412, 1167, 1194, 1168, 1195, 1248, 1202, 1170, 1082, 1035, 1117, 0]

# Result

- Mutation 단계마다 cost를 계산해주기 때문에 time은 2배 가량 늘었지만 best cost 의 개선이 일어났다.
- bad moves를 허용하는 것보다
- 허용하지않고 cost가 뛰어난것만 받아들이는것이 더 좋은 효과를 보였다.

# Result

- Data 1, 2에 대해서는 기존의 코드보다 improve 되었으며

- Data 3 같은 경우에는 기존 코드보다 4정도 나쁜 성능을 보여주고있다.
- ->원인을 추측해보자면 상당히 bad한 moves임에도 불구하고 나중에는 해당 bad moves 로 인해 경로를 크게 줄일 수 있는 경로가 있을것이라고 생각된다.

- Bad moves를 허용해주지 않으면 성능개선이 올바르게 일어난다 (D1, D2, D3 전부)

- Time으로는 손해를 봤지만 cost의 개선이 있었으니 어느 상황에 적용할지에 따라 해당 개선사항이 좋은 개선인지 아닌지 결정될 것 같다.