ЗВІТ

З лабораторної роботи №7

ДОСЛІДЖЕННЯ МУРАШИНИХ АЛГОРИТМІВ

КН-20-1 навчальної групи

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Мета: використовуючи спеціалізовані бібліотеки та мову програмування Python навчитися дослідити деякі типи нейронних мереж.

Завдання 2.1. Дослідження мурашиного алгоритму на прикладі рішення задачі комівояжера

Лістинг коду:

```
import numpy as np
import matplotlib.pyplot as plt
import time

class TravellingAnt:
    def __init__(self, start_city, num_cities):
        self.current_position = start_city
        self.next_position = -1
        self.tabu_list = [self.current_position]
        self.visited_count = 1
        self.travel_path = [self.current_position]
        self.path_length = 0

def initialize_ants(num_ants, num_cities, start_city):
    ants = [TravellingAnt(start_city, num_cities) for _ in range(num_ants)]
    return ants

def update_pheromones(pheromone_matrix, ants, decay_factor=0.5,
pheromone_constant=100, Q=0.5):
    for ant in ants:
        for i in range(len(ant.travel_path) - 1):
            pheromone_matrix[ant.travel_path[i], ant.travel_path[i + 1]] += Q /
ant.path_length
            pheromone_matrix[ant.travel_path[i + 1], ant.travel_path[i]] += Q /
ant.path_length

    pheromone_matrix *= decay_factor

def choose_next_destination(ant, distance_matrix, pheromone_matrix, alpha=1.1,
beta=2.1):
    current_city = ant.current_position
    available_cities = [i for i in range(len(distance_matrix)) if i not in
ant.tabu_list]

    probabilities = [((pheromone_matrix[current_city, city] ** alpha) * (1 /
distance_matrix[current_city, city] ** beta))
                     for city in available_cities]
```

```
    probabilities /= np.sum(probabilities)
    next_city = np.random.choice(available_cities, p=probabilities)

    return next_city

def update_ant_state(ant, next_city, distance_matrix):
    ant.next_position = next_city
    ant.tabu_list.append(next_city)
    ant.visited_count += 1
    ant.path_length += distance_matrix[ant.current_position, next_city]
    ant.current_position = next_city
    ant.travel_path.append(next_city)

def run_ant_colony_optimization(num_ants, num_iterations, distance_matrix,
alpha=1.1, beta=2.2, decay_factor=0.5, pheromone_constant=100, Q=0.5,
start_city=None):
    num_cities = len(distance_matrix)
    pheromone_matrix = np.ones((num_cities, num_cities))

    best_path = None
    best_path_length = np.inf

    start_time = time.time()

    for iteration in range(num_iterations):
        ants = initialize_ants(num_ants, num_cities, start_city)

        for ant in ants:
            for _ in range(num_cities - 1):
                next_city = choose_next_destination(ant, distance_matrix,
pheromone_matrix, alpha, beta)
                update_ant_state(ant, next_city, distance_matrix)

            ant.path_length += distance_matrix[ant.travel_path[-1],
ant.travel_path[0]]

            if ant.path_length < best_path_length:
                best_path_length = ant.path_length
                best_path = ant.travel_path.copy()

        update_pheromones(pheromone_matrix, ants, decay_factor,
pheromone_constant, Q)

    end_time = time.time()
    execution_time = end_time - start_time

    return best_path, best_path_length, execution_time

def plot_cities_path(cities, path):
    path_indices = [i + 1 for i in path]
    vertexes = range(1, len(cities) + 2)

    # Add the starting city at the end to complete the tour
    path_indices.append(path_indices[0])

    fig, ax = plt.subplots(figsize=(12, 8))

    ax.plot(vertexes, path_indices, marker='o', linestyle='-', color='orange',
label='Travel Path')
```

```
    ax.set_yticks(range(1, len(cities) + 1))
    ax.set_yticklabels(cities, fontsize=10)
    ax.set_xticks(vertexes)

    plt.title('Travelling Salesman Problem - Ant Colony Optimization',
fontsize=16)
    plt.xlabel('Cities number', fontsize=14)
    plt.ylabel('Cities name', fontsize=14)
    plt.grid(True, linestyle='--', alpha=0.7)
    plt.tight_layout()
    plt.legend()
    plt.show()

if __name__ == "__main__":
    cities_list = ["Вінниця", "Дніпро", "Донецьк", "Житомир", "Запоріжжя", "Ів-
Франківськ", "Київ",
                   "Кропивницький", "Луганськ", "Луцьк", "Львів", "Миколаїв",
"Одеса", "Полтава",
                   "Рівне", "Сімферополь", "Суми", "Тернопіль", "Ужгород",
"Харків", "Херсон",
                   "Хмельницький", "Черкаси", "Чернівці", "Чернігів"]

    distance_matrix = np.array([
        [np.inf, 645, 868, 125, 748, 366, 256, 316, 1057, 382, 360, 471, 428,
593, 311, 844, 602, 232, 575, 734, 521,
         120,
         343, 312, 396],
        [645, np.inf, 252, 664, 81, 901, 533, 294, 394, 805, 975, 343, 468, 196,
957, 446, 430, 877, 1130, 213, 376,
         765,
         324, 891, 672],
        [868, 252, np.inf, 858, 217, 1171, 727, 520, 148, 1111, 1221, 611, 731,
390, 1045, 591, 706, 1100, 1391, 335,
         560,
         988, 547, 1141, 867],
        [125, 664, 858, np.inf, 738, 431, 131, 407, 1182, 257, 423, 677, 557,
468, 187, 803, 477, 298, 671, 690, 624,
         185,
         321, 389, 271],
        [748, 81, 217, 738, np.inf, 1119, 607, 303, 365, 681, 833, 377, 497,
270, 925, 365, 477, 977, 1488, 287, 297,
         875,
         405, 957, 747],
        [366, 901, 1171, 431, 1119, np.inf, 561, 618, 1402, 328, 135, 747, 627,
898, 296, 1070, 908, 134, 280, 1040,
         798,
         246, 709, 143, 701],
        [256, 533, 727, 131, 607, 561, np.inf, 298, 811, 388, 550, 490, 489,
337, 318, 972, 346, 427, 806, 478, 551,
         315,
         190, 538, 149],
        [316, 294, 520, 407, 303, 618, 298, np.inf, 668, 664, 710, 174, 294,
246, 627, 570, 506, 547, 883, 387, 225,
         435,
         126, 637, 363],
        [1057, 394, 148, 1182, 365, 1402, 811, 668, np.inf, 1199, 1379, 857,
977, 474, 1129, 739, 253, 1289, 1539, 333,
         806,
```

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         1177, 706, 1292, 951],
        [382, 805, 1111, 257, 681, 328, 388, 664, 1199, np.inf, 152, 780, 856,
725, 70, 1052, 734, 159, 413, 866, 869,
         263,
         578, 336, 949],
        [360, 975, 1221, 423, 833, 135, 550, 710, 1379, 152, np.inf, 850, 970,
891, 232, 1173, 896, 128, 261, 1028,
         1141,
         240, 740, 278, 690],
        [471, 343, 611, 677, 377, 747, 490, 174, 857, 780, 850, np.inf, 120,
420, 864, 282, 681, 754, 999, 556, 51, 590,
         300, 642, 640],
        [428, 468, 731, 557, 497, 627, 489, 294, 977, 856, 970, 120, np.inf,
540, 741, 392, 800, 660, 1009, 831, 171,
         548,
         420, 515, 529],
        [593, 196, 390, 468, 270, 898, 337, 246, 474, 725, 891, 420, 540,
np.inf, 665, 635, 261, 825, 1149, 141, 471,
         653,
         279, 892, 477],
        [311, 957, 1045, 187, 925, 296, 318, 627, 1129, 70, 232, 864, 741, 665,
np.inf, 1157, 664, 162, 484, 805, 834,
         193,
         508, 331, 458],
        [844, 446, 591, 803, 365, 1070, 972, 570, 739, 1052, 1173, 282, 392,
635, 1157, np.inf, 896, 1097, 1363, 652,
         221,
         964, 696, 981, 1112],
        [602, 430, 706, 477, 477, 908, 346, 506, 253, 734, 896, 681, 800, 261,
664, 896, np.inf, 774, 1138, 190, 732,
         662,
         540, 883, 350],
        [232, 877, 1100, 298, 977, 134, 427, 547, 1289, 159, 128, 754, 660, 825,
162, 1097, 774, np.inf, 338, 987, 831,
         112,
         575, 176, 568],
        [575, 1130, 1391, 671, 1488, 280, 806, 883, 1539, 413, 261, 999, 1009,
1149, 484, 1363, 1138, 338, np.inf, 1299,
         1065, 455, 984, 444, 951],
        [734, 213, 335, 690, 287, 1040, 478, 387, 333, 866, 1028, 556, 831, 141,
805, 652, 190, 987, 1299, np.inf, 576,
         854,
         420, 1036, 608],
        [521, 376, 560, 624, 297, 798, 551, 225, 806, 869, 1141, 51, 171, 471,
834, 221, 732, 831, 1065, 576, np.inf,
         641,
         351, 713, 691],
        [120, 765, 988, 185, 875, 246, 315, 435, 1177, 263, 240, 590, 548, 653,
193, 964, 662, 112, 455, 854, 641,
         np.inf,
         463, 190, 455],
        [343, 324, 547, 321, 405, 709, 190, 126, 706, 578, 740, 300, 420, 279,
508, 696, 540, 575, 984, 420, 351, 463,
         np.inf, 660, 330],
        [312, 891, 1141, 389, 957, 143, 538, 637, 1292, 336, 278, 642, 515, 892,
331, 981, 883, 176, 444, 1036, 713,
         190,
         660, np.inf, 695],
        [396, 672, 867, 271, 747, 701, 149, 363, 951, 949, 690, 640, 529, 477,
```

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458, 1112, 350, 568, 951, 608, 691, 455,
         330,
         695, np.inf]
    ])

    start_city_index = 6
    num_ants = 20
    num_iterations = 300
    alpha_value = 1
    beta_value = 2
    decay_factor_value = 0.8
    pheromone_constant_value = 100
    Q_value = 1

    best_path, best_path_length, execution_time = run_ant_colony_optimization(
        num_ants=num_ants, num_iterations=num_iterations,
distance_matrix=distance_matrix,
        start_city=start_city_index, alpha=alpha_value, beta=beta_value,
decay_factor=decay_factor_value,
        pheromone_constant=pheromone_constant_value, Q=Q_value
    )

    print("Best Path:", best_path)
    print("Best Path Length:", best_path_length)
    print(f"Execution Time: {execution_time} seconds")
    plot_cities_path(cities_list, best_path)
```

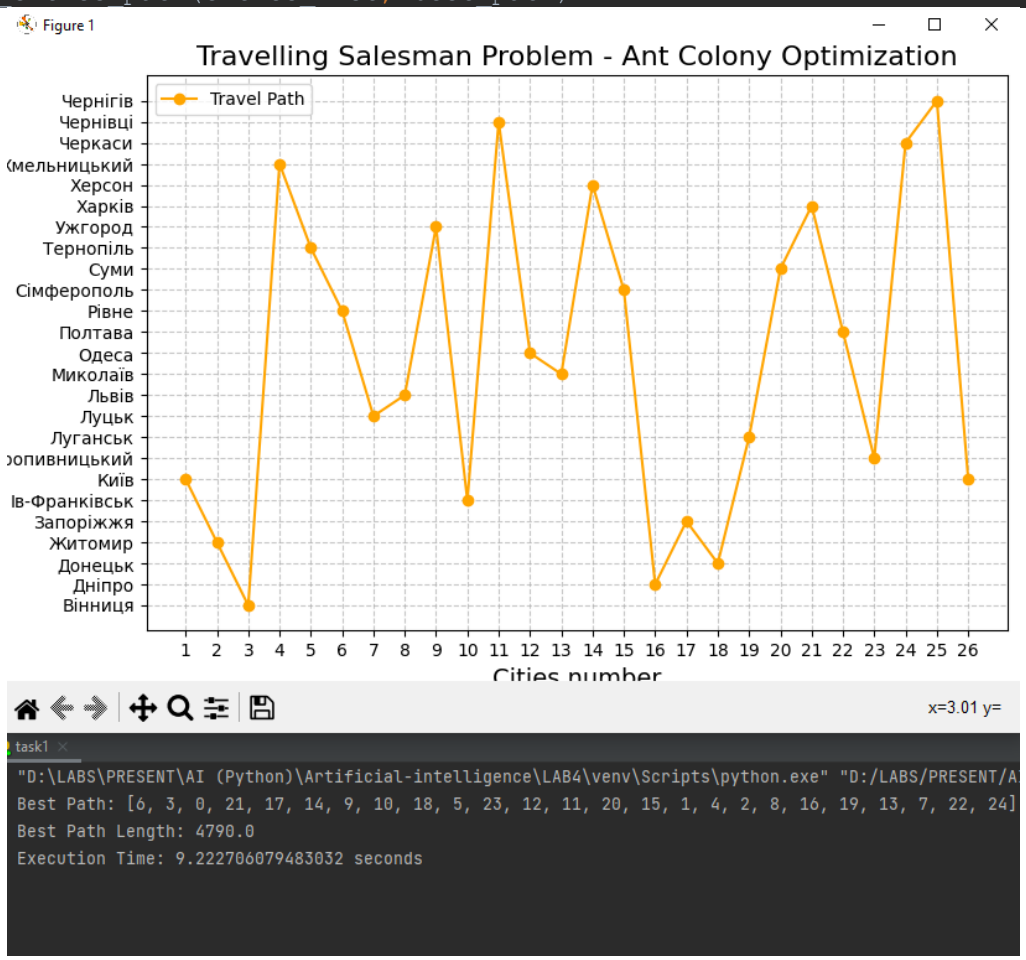

Результат виконання програми.

Параметри	Довжина шляху	Час виконання (сек.)
num_ants = 80 num_iterations = 233 alpha_value = 1.5 beta_value = 2.2 decay_factor_value = 0.5 pheromone_constant_value = 100 Q_value = 1	4979.0	29.5830
num_ants = 30 num_iterations = 265 alpha_value = 1 beta_value = 4.2 decay_factor_value = 0.7 pheromone_constant_value = 100 Q_value = 1	5099.0	2.9191
num_ants = 100 num_iterations = 300 alpha_value = 1.5 beta_value = 4.9 decay_factor_value = 0.9 pheromone_constant_value = 100 Q_value = 1	5041.0	54.2802

Висновки: **Висновки:** використовуючи спеціалізовані бібліотеки та мову програмування Python навчитися дослідив метод мурашиних колоній.

GitHub: https://github.com/invicibleee/Artificial-intelligence.git