Vehicle Routing Problem With Time Windows

— Računarska Inteligencija —

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Beograd, 2024.

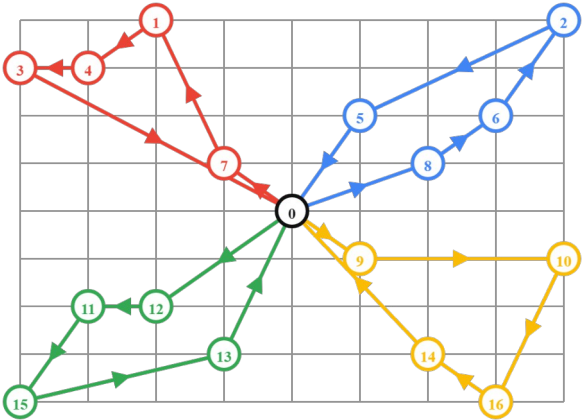
Pregled

Opis problema

Genetski algoritam

Opis problema

- Skup gradova V i skup mušterija C
- Ograničenja
- Funkcija cilja



Genetski algoritam

- Pseudokod

Algorithm 1 Genetski algoritam

```
Create initial population
Evaluate population
while Termination criterion is not met do
    Select good individuals for reproduction
    Perform crossover operation on said individuals
    Perform mutation operation on children individuals with probability P_m
    Evaluate new population
end while
```

- A zapravo...

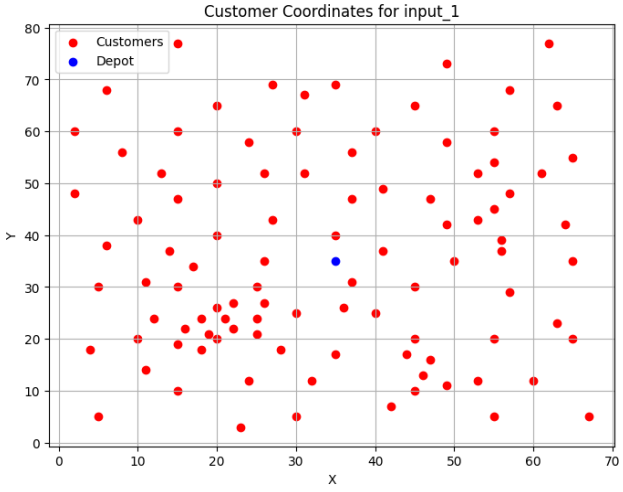
Genetski algoritam

```python
def genetic_algorithm(params):

    data = params["data"]
    capacity = params["capacity"]
    num_of_vehicles = params["num_of_vehicles"]
    service_time = params["service_time"]
    population_size = params["population_size"]
    num_generations = params["num_generations"]
    elitism_size = params["elitism_size"]
    tournament_size = params["tournament_size"]
    mutation_prob = params["mutation_prob"]
    selection_params = params["selection"]

    population = [Individual(data, capacity, num_of_vehicles, service_time) for _ in range(population_size)]
    new_population = deepcopy(population)

    best_solutions = []
    for i in range(num_generations):
        population.sort(key = lambda x: x.fitness)
        best_solutions.append(population[0])
        new_population[:elitism_size] = population[:elitism_size]

        for j in range(elitism_size, population_size, 2):
            parent1 = selection(selection_params, population[:elitism_size])
            parent2 = selection(selection_params, population)

            while(parent1 == parent2):
                parent2 = selection(selection_params, population)

            crossover(params, parent1, parent2, new_population[j], new_population[j+1])

            new_population[j].solution = deepcopy(mutation(params, new_population[j], mutation_prob))
            new_population[j+1].solution = deepcopy(mutation(params, new_population[j+1], mutation_prob))

            offset = min(1/400, 0.25)
            insertion_based_repair(new_population[j], offset)
            insertion_based_repair(new_population[j+1], offset)

            new_population[j].fitness = new_population[j].calc_fitness()
            new_population[j+1].fitness = new_population[j+1].calc_fitness()

            new_population = check_and_update_num_of_vehicles(j, j+1, new_population)

        population = deepcopy(new_population)

    print("Number of vehicles after for loop: ", population[0].num_of_vehicles)
    return min(population, key = lambda x: x.fitness), best_solutions
```

Parametri

```
POPULATION_SIZE = 300
ELITISM_SIZE = 60
MUTATION_PROB = 0.25
TOURNAMENT_SIZE = 50
NUM_GENERATIONS = 30
CAPACITY = 200
SELECTION = [random_selection, tournament_selection, roulette_selection, rang_selection]
MUTATION = [swap_mutation, invert_mutation, shaking_mutation]
CROSSOVER = [order_crossover, partially_mapped_crossover, best_route_better_adjustment_crossover]
NUM_OF_VEHICLES = 50
SERVICE_TIME = 10
```

Skup podataka

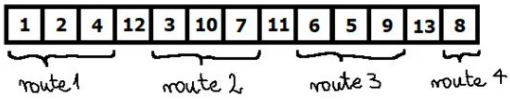


- Marius M. Solomon
- R101

Inicijalizacija hromozoma

Algorithm 2 Inicijalizacija hromozoma

```
1:  Create remaining customers list from available customers
2:  routes = []
3:  last visited = Depot
4:  current route = []
5:  while Remaining customers list is not empty do
6:      Create list of feasible customers and sort it according to distance from last visited customer
7:      if List of feasible customers is empty then
8:          last visited = Depot
9:          Append current route to routes list
10:         current route = []
11:         continue
12:     end if
13:     if random[0, 1] ≤ randomizing parameter then
14:         Choose a random feasible customer and add it to current route
15:         Remove said customer from feasible customers list
16:         Update last visited customer
17:     else
18:         Choose a nearest customer from feasible customer list and add it to current route
19:         Remove said customer from feasible customers list
20:         Update last visited customer
21:     end if
22: end while
```



- Nearest Neighbour heuristika
- Kako postići diverzifikaciju inicijalne populacije?

Inicijalizacija hromozoma

```python
def generate_feasible_routes(self, routes, remaining_cities, prob) -> [[int]]:
    for route in routes:
        while True:
            if not route:
                feasible_cities = self.get_feasible_cities(remaining_cities, 0, 0, self.capacity)
            else:
                _, current_time, remaining_capacity = self.route_fitness(route)
                feasible_cities = self.get_feasible_cities(remaining_cities, route[-1], current_time, remaining_capacity)

            if not feasible_cities:
                break

            if random.random() < prob:
                city_index = random.choice(feasible_cities)[0]
            else:
                city_index = feasible_cities[0][0]

            remaining_cities.remove(city_index)
            route.append(city_index)

            is_unfeasible, _ = self.is_route_unfeasible(route)
            if is_unfeasible:
                route.pop(-1)
                remaining_cities.append(city_index)
                continue
```

Fitness funkcija

```
def route_fitness(self, route) -> (float, float, float):
    if not route:
        return 0, 0, self.capacity

    fitness = 0
    current_time = 0
    previous_city = 0
    remaining_capacity = self.capacity

    for current_city in route:
        current_city_data = self.data[current_city]
        distance = self.distance_between_cities[previous_city][current_city]

        if round(current_time + distance + self.service_time, 3) > current_city_data["due_time"] + self.tolerance:
            fitness += (current_time + distance + self.service_time - current_city_data["due_time"])*self.time_penalty

        if remaining_capacity < current_city_data["demand"]:
            fitness += (current_city_data["demand"] - remaining_capacity)*self.capacity_penalty

        current_time += distance + self.service_time
        previous_city = current_city
        remaining_capacity -= current_city_data["demand"]

    fitness += current_time + self.distance_between_cities[previous_city][0]
    fitness /= len(route) # fitness normalization
    fitness = round(fitness, 3)

    return fitness, current_time, remaining_capacity
```

- Penalizacija
- Normalizacija

Najbolja kombinacija parametara

```
ga_all_combinations.sort(key = lambda x : x[-1][-1].fitness)
best_selection, best_mutation, best_crossover, best_individual_all_comb, best_solutions_all_comb = ga_all_combinations[0]

print('Best selection:', best_selection)
print('Best mutation:', best_mutation)
print('Best crossover:', best_crossover)
print('Best fitness:', best_solutions_all_comb[-1].fitness)

# for s, m, c, p, sol in ga_all_combinations:
#     print(s, m, c, sol[-1].fitness)
```

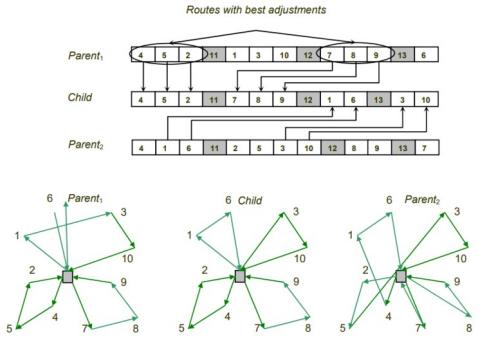
```
Best selection: random_selection
Best mutation: swap_mutation
Best crossover: best_route_better_adjustment_crossover
Best fitness: 567.904
```

Nasumična selekcija

```
def random_selection(population):
    return random.choice(population)
```

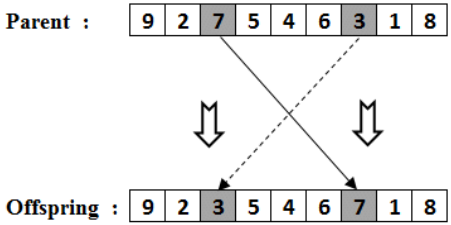
Best Route Better Adjustment Crossover

```
def best_route_better_adjustment_crossover(parent1, parent2, child1, child2):
    # n/2 best from parent1 into first n/2 of child1
    # the rest elements are from parent2

    def create_child(p1, p2, ch):
        p1_routes = p1.get_routes()
        p1_routes.sort(key = lambda route: p1.route_fitness(route)[0])

        offspring = []
        route_idx = 0
        while route_idx <= len(p1_routes) / 2:
            offspring.extend(p1_routes[route_idx])
            route_idx += 1

        p2_routes = p2.get_routes()

        for route in p2_routes:
            for city in route:
                if city not in offspring:
                    offspring.append(city)

        ch.solution = offspring

    create_child(parent1, parent2, child1)
    create_child(parent2, parent1, child2)
```



Swap mutacija

```
def swap_mutation(individual, l, r):
    if l == len(individual.solution):
        l -= 1

    if r == len(individual.solution):
        r -= 1

    individual.solution[l], individual.solution[r] = individual.solution[r], individual.solution[l]
    return individual.solution
```



Insertion Based Repair

```
def insertion_based_repair(individual, offset):
    if (individual.is_feasible()):
        return individual

    routes = individual.get_routes()
    cities = range(1, individual.num_of_cities + 1)
    removed_cities_list = []

    # get unvisited cities
    for city in cities:
        if city not in individual.solution:
            removed_cities_list.append(city)

    # get unfeasible routes
    unfeasible_routes = []
    for route in routes:
        is_unfeasible, _ = individual.is_route_unfeasible(route)
        if is_unfeasible:
            unfeasible_routes.append(route)

    # get feasible routes
    feasible_routes = []
    for route in routes:
        if route not in unfeasible_routes:
            feasible_routes.append(route)

    routes = deepcopy(feasible_routes)
```

Insertion Based Repair

```python
# remove excess routes
if len(routes) > individual.num_of_vehicles:
    routes.sort(key = lambda route: individual.route_fitness(route)[0])
    while len(routes) > individual.num_of_vehicles:
        route = routes.pop(-1)
        removed_cities_list.extend(route)

# remove unfeasible routes
for i, _ in enumerate(unfeasible_routes):
    unfeasible_routes[i].sort(key = lambda x: (individual.data[x]["ready_time"], individual.data[x]["due_time"]))

    # find and eliminate unfeasible cities
    while True:
        is_unfeasible, unfeasible_city = individual.is_route_unfeasible(unfeasible_routes[i])
        if not is_unfeasible:
            break

        removed_cities_list.append(unfeasible_city)
        unfeasible_routes[i].remove(unfeasible_city)
    routes.append(unfeasible_routes[i])
```

Insertion Based Repair

```
# first try: insert if possible in existing route
if len(removed_cities_list) > 0:
    for removed_city in removed_cities_list:
        is_inserted = False
        for route_index, _ in enumerate(routes):
            for city_index, _ in enumerate(routes[route_index]):
                route_copy = deepcopy(routes[route_index])
                route_copy.insert(city_index, removed_city)

                is_unfeasible, _ = individual.is_route_unfeasible(route_copy)
                if not is_unfeasible:
                    routes[route_index] = deepcopy(route_copy)
                    is_inserted = True
                    removed_cities_list.remove(removed_city)
                    break

            if is_inserted:
                break
```

Insertion Based Repair

```
# second try: create new routes
if len(removed_cities_list) > 0 and individual.num_of_vehicles - len(routes) > 0:
    new_routes = [[] for _ in range( individual.num_of_vehicles - len(routes) )]
    generated_routes = individual.generate_feasible_routes(new_routes,
                                                           removed_cities_list,
                                                           0.25 - offset)
    routes = routes + generated_routes

individual.solution = individual.create_solution(routes)
```

Optimizacija parametara za najbolju kombinaciju operatora

```
POPULATION_SIZE = list(range(500, 1000, 100))
ELITISM_SIZE = list(range(70, 140, 14))
MUTATION_PROB = 0.25
TOURNAMENT_SIZE = 50
NUM_GENERATIONS = list(range(30, 50, 5))
CAPACITY = 200
SELECTION = globals().get(best_selection)
MUTATION = globals().get(best_mutation)
CROSSOVER = globals().get(best_crossover)
NUM_OF_VEHICLES = 50
SERVICE_TIME = 10
```

```
Best population size: 700
Best number of generations: 35
Best elitism size: 70
Best fitness: 541.695
```

Optimizacija parametara za najbolju kombinaciju operatora

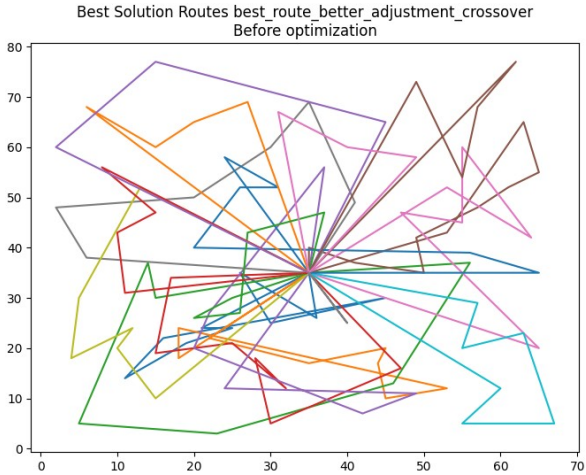
```
ga_analysis(best_crossover, best_individual_all_comb)
```

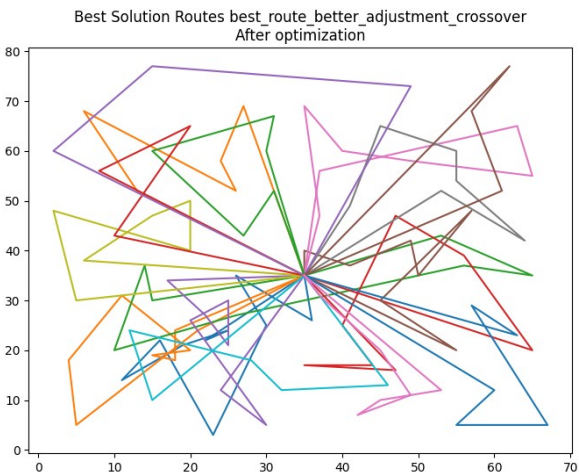
```
best_route_better_adjustment_crossover - is feasible
best_route_better_adjustment_crossover - num of non empty routes: 18
best_route_better_adjustment_crossover - total num of routes: 18
best_route_better_adjustment_crossover - fitness: 567.904
```

```
ga_analysis(best_crossover, best_individual_opt)
```

```
best_route_better_adjustment_crossover - is feasible
best_route_better_adjustment_crossover - num of non empty routes: 17
best_route_better_adjustment_crossover - total num of routes: 17
best_route_better_adjustment_crossover - fitness: 541.695
```

Optimizacija parametara za najbolju kombinaciju operatora





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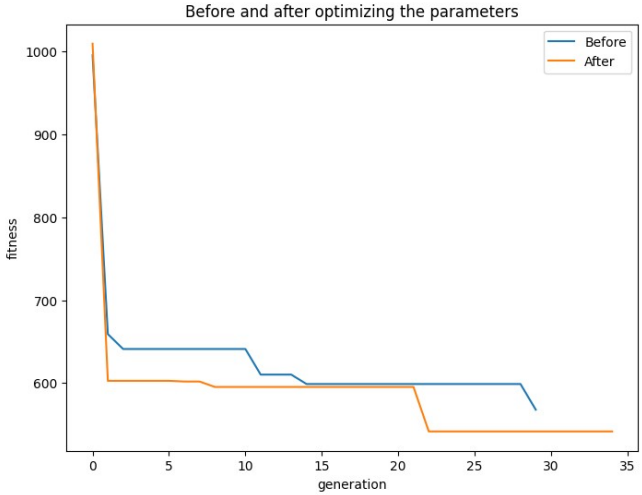

Hvala na pažnji!