AN EVOLUTIONARY APPROACH FOR SOLVING VEHICLE ROUTING PROBLEM FOR 32 CITIES IN SLOVAK REPUBLIC

Zuzana Čičková, Ivan Brezina

Vehicle Routing Problem (VRP)

We assume:

- depot
- customers with certain demand
- vehicle with certain capacity
- distance (length, cost, time) matrix between the customers and the depot

Goal: designing the optimal set of routes for a vehicle in order to serve a given set of customers

The interest: it is motivated by its practical relevance as well as by its computational complexity (NP–hardness)

Methods classification by its implementacion principle:

- **Explicit enumeration**
- **Deterministic methods** - Branch and Bound Algorithm, Cutting Plane Method, Dynamic Programming etc.
- **Stochastic methods** - Monte Carlo, Random search Walk, Evolutionary Computation etc.
- **Combined methods** - Ant Colony Optimization, Memetic Algorithms, Genetic algorithms etc.

Evolutionary algorithms (EA)

- Use mechanisms inspired by biological evolution, such as reproduction, mutation, recombination and natural selection
- EA for constrained problems:

1) Methods based on penalties functions which penalize unfeasible solutions
2) Methods which make a clear distinction between feasible and unfeasible solutions
3) Methods using special reproduction operators to preserve feasibility of solutions
4) Hybrid methods

PRINCIPLES OF SOMA

- Individual – set of arguments of objective function (*d* – dimensionality, number of arguments)
- Population – set of Individuals (np – number of individuals in the population)
- Fitness – relevant value of objective function for each Individual

	$f_c(\mathbf{x}_i)$	1	2		d
$\mathbf{x}_1$	$f_c(\mathbf{x}_1)$	x_{11}	x_{12}		x_{1D}
$\mathbf{x}_2$	$f_c(\mathbf{x}_2)$	x_{21}	x_{22}		x_{2D}
$\mathbf{x}_{np}$	$f_c(\mathbf{x}_{np})$	x_{np1}	x_{np2}		x_{npd}

Population

SOMA

1) parameters setting
2) initialization of population
3) evaluation of individuals
4) testing the stopping condition –
   if yes 6), otherwise 5)
5) migration loop and back to 3)
6) results interpretation

Parameters setting

- *d* - dimensionality. Number of arguments of objective function.
- *np* – population size. It depends of user and his hardware. Parameter *np* does not changes during minimization process.
- *m* – migrations. Represent the maximum number of iteration. Insufficient value of *m* value could results in reaching not optimal solution.
- *mass* – path length, *mas*s. Represents how far an individual stops behind the leader.
- *step* – *d*efines the granularity with what the search space is sampled.
- *prt* – perturbation, *prt*. Determines whether an individual travel directly towards the leader or not.

Migration loop

- Leader: max $f_c(x_i)$
- jumping towards the Leader

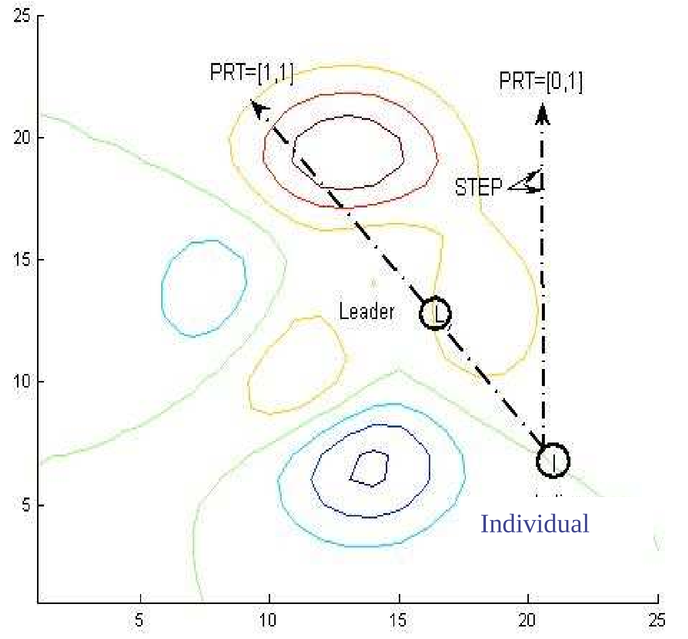
$$x_{i,j}^{mk+1} = x_{i,j,start}^{mk} + (x_{L,j}^{mk} - x_{i,j,start}^{mk})tprt_j$$

$$t \in \langle 0, \text{by } step \text{ to } mass \rangle$$

- Individual returns to that position, where the best fitness was found:

$$x_{i,j}^{mk+1} = \min\left\{ f_c(x_{i,j}^{mk}), f_c(x_{i,j,start}^{mk} \right\}$$

$$\text{PRT}_j = \begin{cases} 1, \text{ ak } rand_j \langle 0,1 \rangle > prt \\ 0, \text{ otherwise} \end{cases}$$



SOMA for VRP

- natural representation of individual (customer cities are listed in the order in which they are visited)
- fitness represents the cost of corresponding tour
- initialization of population

$$P^{(0)} = x_{i,j}^{(0)} = \text{randperm}(d)$$
$$i = 1, 2, \dots, np \quad j = 1, 2, \dots, d$$

Input data

- parameters setting
  - d – number of customer cities = 14
  - np = 50
  - mig = 200
  - mass = 3
  - prt = 0.8
  - step = 0.9

Input data

- **vehicle capacity:** 50 units
- **customer cities + demand:**

BA – 6,94 units, KN – 6,97 units, MA – 2,63 units, NR – 5,49 units, PB – 3,77 units, PD – 9,19 units, PE – 3,42 units, PK – 5,73 units, PN – 5,02 units, SI – 1,85 units, TN – 11,76 units, TO – 2,81 units, TT – 13,88 units, ZA – 8,69 units

- **central depot:** SER
- **distance matrix** (shortest distances in km) between the customers and the depot was obtained from MS AutoRoute

Final results

- 10 simulation
- tour length 707 km
- e.g <u>SER</u> – PN – TN – PB – ZA – PD – PE – TO – <u>SER</u> – TT – SI – MA – PK – BA – KN – NR – <u>SER</u>
- GAMS – model of mathematical programming – tour length 707 km