technische universität
dortmund

Dept. of Computer Science
Chair of Algorithm Engineering

Tutorial for

# Introduction to Computational Intelligence in Winter 2015/16

Günter Rudolph, Vanessa Volz

Lecture website: `https://tinyurl.com/CI-WS2015-16`

## Sheet 5, Block I

14 January 2016

**Due date: 27 January 2016, 2pm**
**Discussion: 28/29 January 2016**

### Exercise 5.1: Variation Operations (8 Points)

(a) Assume $x, y \in \mathbb{R}$ are individuals in a population. Let the value of $x$ at timestep $t$ be $x_t$, with $x_t = m_l(x_{t-1})$ where $m_l$ is a local mutation operation and $x_0 = 0$. Similarly, let the value of $y$ at timestep $t$ be $y_t$, with $y_t = m_n(x_{t-1})$ where $m_l$ is a nonlocal mutation operation and $y_0 = 0$. Choose $m_l$ and $m_n$ appropriately and compute all values $x_t, y_t$ for $t \in [1, 1000]$. Plot all tuples $(t, x_t)$ and $(t, y_t)$, describe the resulting graphs and explain all patterns you detect.

(b) Now assume $\vec{x}, \vec{y} \in \mathbb{B}^{10}$ are individuals in a population. Like in task (a), choose appropriate mutation operations ($m_l$ local and $m_n$ nonlocal) and compute the values $x_t, y_t$ for $t \in [1, 1000]$ as defined above, with $x_0 = (0,0,0,0,0,0,0,0,0,0,0)^T = y_0$. Plot the results by converting the values $x_t$ and $y_t$ to values in $\mathbb{N}$. Try both standard and grey encoding. Describe the resulting graphs and explain all patterns you detect.

(c) Now assume we have a population of two individuals $\vec{x}, \vec{y} \in \mathbb{R}^2$. They are located at $\vec{x} = (0,0)^T$ and $\vec{y} = (1,1)^T$. Create 1000 offspring by intermediate, intermediate per dimension, and discrete recombination from the two parents $\vec{x}$ and $\vec{y}$ (no mutation). Plot the offspring of each of the operators in a seperate figure and explain all patterns you detect.

### Exercise 5.2: Variation Operations (8 Points)

Meet Emma. Emma is a sales person that wants to visit the cities $A, B, C, D, E$ exactly once to sell goods. The travelling costs between the cities are defined in the following matrix, where $c_{A,B}$ is the cost to travel from city $A$ to city $B$:

| $c$ | $A$ | $B$ | $C$ | $D$ | $E$ |
|---|---|---|---|---|---|
| $A$ | 0.0 | 3.0 | 2.5 | 6.7 | 4.0 |
| $B$ | 3.0 | 0.0 | 1.1 | 6.5 | 5.1 |
| $C$ | 2.5 | 1.1 | 0.0 | 5.5 | 4.0 |
| $D$ | 6.7 | 6.5 | 5.5 | 0.0 | 3.2 |
| $E$ | 4.0 | 5.1 | 4.0 | 3.2 | 0.0 |

Implement an (1+1)-EA that minimises the cost of the whole tour. Try different variation operators and parameters. What would a local optimum be in this context? Does your EA find a local or global optimum and/or converge? If it does, after how many function evaluations?

**Exercise 5.3: Offspring fitness** (4 Points)

$$f_c(x_1, x_2) = x_1^2 + x_2^2 \text{ with } (x_1, x_2) \in \mathbb{R}^2$$
$$f_e(x_1, x_2) = x_1^2 + \frac{1}{4}x_2^2 \text{ with } (x_1, x_2) \in \mathbb{R}^2$$
$$f_r(x_1, x_2) = x_1^2 + x_2^2 - 10(\cos(2\pi x_1) + \cos(2\pi x_2)) + 20 \text{ with } (x_1, x_2) \in [-5, 5]^2$$

Set up an experiment that tests the theorem from lecture 9, slide 27 for the functions $f_c, f_e, f_r$ defined above for individuals $\vec{x}, \vec{y} \in \mathbb{R}^2$ of your choosing.