technische universität dortmund

Dept. of Computer Science
Chair of Algorithm Engineering

Tutorial for

Introduction to Computational Intelligence in Winter 2015/16

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

Sheet 6, Block III

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Due date: 10 February 2016, 2pm
Discussion: 11/12 February 2016

Exercise 6.1: Basic Probability Theory (4 Points)
Consider standard-bit-mutation on a bitstring of length n where the probability of flipping is $p = 1/n$ for each bit.

a) Calculate the probability that a certain bit is flipped at least once within t mutations.

b) Calculate the probability that exactly k bits of the bitstring are flipped in one mutation.

c) Given a bitstring x, calculate the probability that a certain bitstring y is the result of one mutation of x. Hint: Use the Hamming distance to relate bitstrings to each other.

d) Calculate the expected number of flipped bits per mutation.

Exercise 6.2: Real-valued Optimization (3 Points)
Download and install the R-package `cmaes` (`install.packages("cmaes")`). This package also contains the three test problems `f_sphere`, `f_rastrigin`, and `f_rosenbrock` (to be minimized). Compare the CMA-ES algorithm with the optimizer `rbga` in the package `genalg` (`install.packages("genalg")`) on these three problems. Repeat each algorithm at least 10 times for $n = 10$ decision variables. The number of function evaluations shall be fixed to 10000 and the search space be restricted to $[-5, 5]^n$. Average the obtained function values of the best solutions. Plot, report, and interpret the results.

Exercise 6.3: SMS-EMOA (9 Points)
You are playing a paladin in a video game and have three different attacks available. The mana needed to cast a spell and the damage caused are detailed in the table:

name	damage [HP]	mana [MP]
Avenger's Shield	4	1
Hammer of Wrath	3	1
Holy Nova	4	3

You have 5 mana available. Your goal is to select a combination of attacks that maximises the damage output while at the same time minimising mana consumption.

a) Plot the objective values of all possible solutions. Identify the non-dominated set. In a scenario with an opponent with 4 health points, which attack combination would you choose?

b) Assume you wanted to solve the problem as a single-objective minimisation problem and use the sum of the two objectives as a fitness value. Calculate the fitness value for all solutions. Discuss if there are any problems with aggregating the objective values with a weighted some for this problem.

c) You now want to solve the problem as a multi-objective minimisation problem using the SMS-EMOA algorithm. Use a populations size of $\mu = 3$ with random initialisation, uniform crossover and global mutation with $p_m = \frac{1}{n}$ (n is the length of your genes). For a budget of 7 function evaluations calculate the result of the SMS-EMOA-run by hand. Detail all calculation steps and assume your random number generator results in the sequence of numbers in file randNo.txt.

Exercise 6.4: Variation operator Design (4 Points)

a) Approximate the entropy of the following distributions using their R implementations and verify that the normal distribution has the maximum value:

- normal distribution with mean $\mu = 0$ and variance $\sigma^2 = 4$: $N(0, 2)$
- student-t distribution with $\frac{8}{3}$ degrees of freedom
- laplace distribution with location $\mu = 0$ and scale $b = \sqrt{2}$

```
dLaPlace = function(x, mu, b){
  return((1/(2*b))*exp(-abs(x-mu)/b))
}
```

Listing 1: `laPlaceDensity.R`

b) The parameters of the above functions are selected so that all distributions have a mean of 0 and a variance of 4. Why is that necessary when comparing the values of their entropy?