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Applied Evolutionary Optimization
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Tutorial 2: Evolutionary Optimization

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1. We would like to use a binary-coded genetic algorithm to solve the following NLP problem:

$$\begin{array}{ll} \text{Minimize} & (x_1 - 1.5)^2 + (x_2 - 4)^2 \\ \text{subject to} & 4.5x_1 + x_2^2 - 22.5 \leq 0, \\ & 2x_1 - x_2 - 1 \geq 0, \\ & 0 \leq x_1, x_2 \leq 4. \end{array}$$

   We decide to have two and three decimal places of accuracy for variables x_1 and x_2, respectively.

   (a) At least how many bits are required for coding the variables?

   (b) Use the penalty-parameter-less fitness assignment procedure to compute the fitness of the following population members: (i) (2,1,) (ii) (6,2), (iii) (0,3), (iv) (3,0), (v) (1,-1), (vi) (2.5,2)

2. For a maximization problem, an initial population of binary strings and their fitness values are shown below:

String	Fitness
$\cap\cup\cap\cup\cup\cap$	15
$\cup\cup\cap\cap\cap\cup$	5
$\cap\cap\cup\cup\cap\cap$	14
$\cup\cap\cup\cap\cup\cup$	8
$\cup\cup\cap\cap\cup\cup$	7
$\cap\cup\cup\cup\cap\cup$	10

   Using crossover and mutation probabilities $p_c = 0.8$ and $p_m = 0.1$, estimate using schema theorem how many strings representing the schema ($\cap * * \cup * *$) would be produced after one iteration of GAs with roulette-wheel reproduction, single-point crossover, and bit-wise mutation operators. Which of the two schemata ($\cap * * * * *$) and ($\cup * * * * *$) is likely to take over the population in a GA run with above parameter setting? Give reasons.

3. We would like to find all four maxima of the following multimodal function defined in the range $x_1, x_2 \in [0, 1]$ using GAs with sharing functions:

$$F(x_1, x_2) = (1 - x_1 - x_2) \sum_{i=1}^{2} f_i(x_i),$$

   where $f_i(x_i) = \sin^2(2\pi x_i)$. Assume optima lie at $x_1, x_2 = 0.25$ and 0.75. To avoid the stochastic sampling error, we require at least 5 copies at each optimum. What should be the minimum population size?