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SC2: Evolutionary Methods for Single and Multi-Objective Optimization

Assignment II: Evolutionary Single-Objective Optimization

Marks: 25

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1. We would like to use genetic algorithms to solve the following NLP problem:

$$\text{Minimize} \quad (x_1 - 1.5)^2 + (x_2 - 4)^2$$

subject to

$$4.5x_1 + x_2^2 - 18 \leq 0,$$
$$2x_1 - x_2 - 1 \geq 0,$$
$$0 \leq x_1, x_2 \leq 4.$$

We decide to have three and two decimal places of accuracy for variables x_1 and x_2, respectively. (6)

   (a) How many bits are required for coding the variables?

   (b) Write down the fitness function which you would be using in the selection operator.

   (c) Which schemata represent the following regions according to your coding:

   (a) $0 \leq x_1 \leq 2$,

   (b) $1 \leq x_1 \leq 2$, and $x_2 > 2$.

2. In a genetic algorithm simulation, the following population is observed at generation four:

Strings	Fitness
`0101101`	10
`1001001`	8
`1010110`	14
`0111110`	20
`1110111`	2
`0111100`	12

If the roulette-wheel proportionate selection, the single-point crossover with probability 0.9, and the bit-wise mutation with a probability 0.01 are used, answer the following questions: (5)

   (a) How many copies of the schema `(*1*11**)` are expected in generation five?

   (b) Of the two schemata `(0******)` and `(1******)`, which one is likely to increase with generations and why?

3. Using real-coded GAs with simulated binary crossover (SBX) having $\eta = 2$, find the probability of creating children solutions in the range $0 \leq x \leq 1$ with two parents $x^{(1)} = 0.5$ and $x^{(2)} = 3.0$. Recall that for SBX operator, the children solutions are created using the following probability distribution:

$$\mathcal{P}(\beta) = \begin{cases} 0.5(\eta+1)\beta^{\eta}, & \text{if } \beta \leq 1; \\ 0.5(\eta+1)/\beta^{\eta+2}, & \text{if } \beta > 1. \end{cases}$$

where $\beta = |(c_2 - c_1)/(p_2 - p_1)|$ and c_1 and c_2 are children solutions created from parent solutions p_1 and p_2. (5)

4. Answer the following questions in brief: (9)

   (a) Write at least three reasons explaining why a binary-coded GA may not be suitable in solving real-parameter optimization problems.

   (b) Explain why for a fixed number of overall function evaluations, too small or too large a population size may not be result in an effective application of an evolutionary algorithm.

   (c) If in a problem, first-order gradient of the objective and constraint functions are available, how would you utilize them in designing an efficient evolutionary algorithm?