COMSM0302 - WEEK 1 EXERCISES

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1. Exercise 1 - Simple GA for *Onemax* function

Implement the Simple Genetic Algorithm described in lecture 1, in a language of your choice, on the *Onemax* function. The program should take as parameters the population size N, crossover rate χ, mutation rate μ and problem size ℓ.

2. Exercise 2 - Effects of mutation under standard and Gray binary encoding

Calculate the expected deviation in encoded integer resulting from a single uniformly selected point mutation in a 4-gene binary chromosome, under standard binary and Gray binary reflected encodings. Also calculate the variance of the expectation. Write a computer program to help you if necessary.

Hint: The question is, if one mutates a random gene in a randomly selected chromosome, what is the expected difference in the integer that chromosome encodes before and after mutation? An expectation is the same as a mean. The expectation should be taken over all possible single point mutations of all possible chromosomes, and by the definition of point mutation all mutations are equally likely. Assume that all chromosomes are equally likely too. The variance σ^2 can be calculated as

$$\sigma^2 = \frac{\sum_{k}^{n}(x_k - \mu_X)^2}{n},$$

where x_k is a single value used in the calculation of the expectation and μ_X is the mean or expected value itself (i.e. $\mu_X = E(X)$).

3. Exercise 3 - Sparseness of permutation encoding

For a problem whose solutions are permutations of 5 objects, what proportion of chromosomes encoded using one gene per position in the permutation are valid solutions? Derive a general expression for encodings with ℓ genes and alleles.

Hint: There is a simple way of calculating how many permutations there are of a set of n items, and you should be familiar with calculating how many unique strings of length ℓ there are in a specified base.

4. Exercise 4 - Positional bias of crossover operators

Calculate the probability of two alleles with l genes between them, on a parental chromosome of length ℓ, ending up together in the same offspring chromosome, for 1X, for 2X, and for UX with arbitrary p (assume two offspring are created by the crossover operators)

Hint: For each operator, work out all the possible situations in which both alleles end up in the same offspring chromosome. Calculate the probability of each of these situations.