NAT Tutorial 3 (week 5)

1. [Baldwin effect] It has been observed that some organisms seem to pass on behaviours learned during their lifetime to their offspring. Lamarck's hypothesis was that traits acquired during the lifetime of an individual could somehow be passed on genetically to the individual's children. Until the recent past, however, Lamarck's hypothesis was universally rejected, because there seemed to be no obvious biological mechanism for this. Today, one admits that Lamarckian inheritance is in principle not impossible and that Lamarck's theory of evolution and development cannot be reduced to the inheritance of acquired traits.
   One proposal for a non-Lamarckian mechanism explaining the passing on of learned behaviours was given by Baldwin, who pointed out that if learning helps survival, then the organisms best able to learn will have the most offspring (highest fitness). Further, if the environment remains constant, so that the best things to learn remain constant, then this can lead, via selection, to a genetic encoding of a trait that previously had to be learned. Describe how you could use evolutionary computation as a model system to demonstrate the truth (or otherwise) of Baldwin's hypothesis.
   Another important feature of Baldwinian evolution is the identifiability of isolated fitness maxima. How would this be possible?
2. (Mitchell) Design a three bit fully deceptive fitness function. "Fully deceptive" means that the average fitness of every schema indicates that the complement of the global optimum is actually the global optimum. For example, if 111 is the global optimum, any schema containing 000 should have the highest fitness in its partition.
3. How can elitism be achieved in an application of GA to multi-objective optimisation? Visualise the situation for the case of two fitness functions. What issues can be expected to arise for a large numbers of objectives?
4. A (1+1)-ES performs essentially only hill climbing. Give an estimate of the time to reach the minimum of the function $f(x)=(x-5)^2$ when starting from $x=0$. This estimate will depend on the size of the mutation steps and the required accuracy.
   What strategy would you choose for Rastrigin's function in n dimensions
   $f(x)=10\,n+\Sigma\,(x_i^2-10\cos(2\pi\,x_i))$ [the sum runs from $i=1$ to n]. Discuss the dependency of μ and λ on n (start with considering $n=1$) for a (μ,λ)-ES and a $(\mu+\lambda)$-ES and reasonable choices of the parameters and rules for mutability.
5. Genetic programming (GP) is an evolutionary technique which attempts to evolve programs fit for some purpose. Describe a typical GP system: explain how programs are represented in the system; give examples of the genetic operators applied; and state the main steps of the evolutionary algorithm indicating where there are design choices to make.
6. Express the following functions in Lisp notation, using only + − / as non-terminals and x, 0, 1, 2, 3, . . . as terminals.
   a) $y = 3x + 2$
   b) $y = 5x^4 - 2x^2$
   c) $y = -0.25x^3 + 3.5$
   Which of these functions can you represent using only x and 1 as terminals?
7. What fitness function can GP use for solving symbolic regression problems? Can you think of any alternatives? How much domain specific knowledge about the problem is encoded in this fitness function?
8. Do schemata and building blocks exist in Genetic Programming populations?