

NAT Tutorial 7: Molecular Computing and Revision

1. Write Adleman's algorithm for the Hamiltonian Directed Path Problem (HDPP) using the Adleman-Lipton or the sticker model.
2. Design a DNA algorithm for the N -queens problem.
3. Explore L-systems (<http://nolandc.com/sandbox/fractals/>) and consider the relation between L-systems and genetic algorithms, see http://www.biologie.uni-hamburg.de/b-online/e28_3/lsys.html
4. Consider the example for computations in a P-system from the lecture and represent it as a system of concatenated automata.
5. (Repeated from 6th Tutorial) Look at http://www.inf.ed.ac.uk/teaching/exam_papers/ for problems in previous years' exams of the courses Natural computing (NAT) and Genetic algorithms and genetic programming (GAGP). Identify at least one problem which is not easily solvable.

From past exams:

6. The Boolean satisfiability problem is as follows: given a formula in conjunctive normal form, find an assignment of Boolean values to the variables in the formula which make the entire formula true. A formula in conjunctive normal form is a conjunction (and) of a set of clauses, with each clause being a disjunction (or) of atomic variables or negated atomic variables. For example:
(L1 OR L2 OR NOT L3) AND (L3 OR NOT L4 OR NOT L5) AND (NOT L2 OR L4 OR L5)
 - (i). Describe how you could apply the canonical genetic algorithm to the Boolean satisfiability problem.
 - (ii). How could you improve upon your canonical GA solution for this problem?
7. 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. However, since there is no obvious biological mechanism for this, Lamarck's hypothesis is universally rejected.
On proposal for a non-Lamarckian mechanism explaining the passing of learned behaviour was given by Baldwin, who pointed out that if learning helps survival, then the organisms best able to learn will have most offspring. 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.
 - (a) Describe how you could use evolutionary computation as a model systems to demonstrate the truth (or otherwise) of Baldwin's hypothesis.
 - (b) Lamarck's hypothesis a useful concept in evolutionary computation? Consider the impact of the hypothesis on both evolutionary optimization and the evolution of intelligent agents.
8. Your company has the task of designing controllers for spaceships in the "Killer Asteroid" computer game: asteroids travel across the screen destroying any

spaceship they hit, unless the spaceship fires at the asteroid and destroys it first. The spaceships' aim is to survive for as long as possible. Spaceships may move by firing two thrusters, one on each side of the spaceship; the spaceships are working in a gravity-free environment so firing the thrusters causes a spaceship to translate or rotate or both. A spaceship's missiles are ejected from its nose, so the spaceship must be pointing in the right direction if a missile is to intersect the path of the asteroid. Assume a spaceship has sensors looking in 8 quadrants around it that can measure quantities like distance to nearest asteroid in each quadrant, speed of asteroid, bearing of asteroid with respect to the spaceship, etc. Describe how you would use GP to come up with a controller for a spaceship, giving details of and justifying all assumptions you make.

Discuss the problems your solution might have in evolving good controllers in a short time. How would your solution fare if the game is made more complicated, e.g. by requiring the spaceships to avoid each other or allowing them to hide behind planets.

9. How many schemas does the string 1001001110 sample? Give an example schema sampled by this string.
10. The Bigbooks book company want to deliver its books to stores around the country. It hires lorries from Toptrucks and delivers several parcels to each store. Each lorry starts at Bigbooks's depot, where it is filled with parcels. Bigbooks wishes to hire as few lorries as possible so the space inside them needs to be used efficiently, and it wishes to use as little fuel as possible, so the distance travelled by the lorries should be as short as possible. You may assume that weight is not an issue, i.e. a fully loaded lorry is not too heavy. How would you use ACO to produce routes for the lorries? In your answer be sure to describe the use you make of heuristics. How can local heuristics be employed in ant colony optimisation problems?
11. Describe one crossover and one mutation mechanism that would be suitable for use with real-valued chromosomes. In each case use an example to illustrate your answer.
12. State the schema theorem briefly, using either words or an equation. Why might the schema theorem not give an accurate prediction of a GA's performance?
13. What characteristics of an optimisation problem do you need to consider when deciding whether to solve it using a GA or GP? What are the advantages and disadvantages of using GP especially when compared to using a GA?
14. How can a genetic algorithm be used to evolve a plan? Give details of all the steps involved. What changes must be made in a genetic algorithm to obtain a steady-state genetic algorithm?