

# NAT Tutorial 5: Particle Swarm Optimization

1. Consider **one** of the following problems (or any other one that seems to be interesting) and explain how you would use ant colony optimization to find an acceptable solution: Sequential ordering, classification (e.g. of images), graph colouring, the knapsack problem (or the cutting stock problem), protein folding, the shortest common supersequence problem (for details cf. wikipedia). For this purpose, Dorigo has suggested to answer the following questions:
  - a) Define a set of candidate solutions and the set of feasible solutions.
  - b) Define a greedy construction heuristic:
    - i) What are the solution components?
    - ii) How do you measure the objective function contribution of addition a solution components
    - iii) Is it always possible to construct feasible solutions?
    - iv) How many different solutions can be generated with the constructive heuristic?
  - c) Define a local search algorithm:
    - i) How can local changes be defined?
    - ii) How many solution components are involved in each local search step?
    - iii) How do you choose which neighbouring solution to move to?
    - iv) Does the local search always maintain feasibility of solutions?
2. Consider a particle “swarm” consisting of a single member. How would it perform in a trivial task such as the minimization of  $f(x)=x^2$ ? How in a more complex problem? How is diversity produced in a particle swarm of many members?
3. How would you adapt particle swarm optimization to the travelling salesperson problem?
4. Compare the function of the algorithms for particle swarm optimisation and differential evolution.
5. Run some example simulations (Start MASON below “Applets and Screenshots”) at <http://cs.gmu.edu/~eclab/projects/mason/> E.g.: Ant Foraging, Flockers, HeatBugs and in particular Particle Swarm Optimization (click “Model” to change parameters) Another visualizer is at [www.projectcomputing.com/resources/psovis/index.html](http://www.projectcomputing.com/resources/psovis/index.html) (PSO only)
6. How are social behaviours in living organisms helpful in developing optimization techniques? Think of examples other than foraging ants, see e.g. [www.red3d.com/cwr/ibm.html](http://www.red3d.com/cwr/ibm.html) (meant as an inspiration not as a reading list)
7. Considering the application of the particle swarm optimization to the travelling salesperson problem, how would you encode a bin-packing problem (see the ACO lectures) in an particle swarm?
8. Discuss the combination of PSO and particle filters. See Lectures on PSO and the mentioned paper:  
G. Tong, Z. Fang, X. Xu (2006) A particle swarm optimized particle filter for nonlinear system state estimation, <http://portal.acm.org/citation.cfm?id=1389095.1389104>
9. Go through the resources at [bingweb.binghamton.edu/~sayama/SwarmChemistry/](http://bingweb.binghamton.edu/~sayama/SwarmChemistry/) in particular read Sayama’s article on “Hyperinteractive Evolutionary Computation”