MAE 552 – Heuristic Optimization | Homework #1
Due Date: Friday Feb 8, 2002 | Instructor: Dr. Kurt Hacker

Problem One

In a heuristic search algorithm, one of the primary goals is to balance the global and local search components. Discuss how this balance is problem dependent in terms of the size of the search space, the presence or absence of constraints, the shape of the response surface (i.e. the topography of the design space), the difficulty or ease of calculating the objective function and constraints, and the user requirements for near optimality in the solution.

Answers:

1 Size of the Search Space – If the search space is small then it is possible to use truly provable global search methods like enumerative search and other brute force methods. Larger search spaces require taking a more local approach, with some global and local characteristics in the algorithm.

2 Constraints – constraints do two things, limit the size of the search space and make it harder for an algorithm to follow a series of increasingly improving solutions. Global search methods tend to become more inefficient (but they are still useful) because most do not 'follow constraints' and may consider many infeasible solutions. Some local search methods can efficiently handle constraints but may become stuck.

3 Shape of response Surface – If the response surface (shape of the evaluation function) is convex or nearly convex then pure local search is often the best choice. As it becomes increasingly mutimodal a larger global search component is needed.

4 The difficult or ease of calculating the evaluation function greatly affects the type of search that can be performed. If only a few function evaluations can be afforded then it would not be possible to run a global search, which can take many function evaluations. If the evaluation function is cheap then a more global search can be executed.

5 If the user requires the absolute global optimum design then the only choice may be a brute force global method which enumerates every possible solution. If only a near optimal solution is needed then many local methods can provide good solutions with much less cost.

Problem Two

You are presented with the following unconstrained optimization problem.

Minimize $\mathbf{F}(\mathbf{x}) = [4 - 2.1\mathbf{x}_1{}^2 + \mathbf{x}_1{}^4/3]\mathbf{x}_1{}^2 + \mathbf{x}_1\mathbf{x}_2 + [-4 + 4\mathbf{x}_2{}^2]\mathbf{x}_2{}^2$

$-3 \le \mathbf{x}_1 \le 3$

$-2 \le \mathbf{x}_2 \le 2$

You must use three methods to solve this problem.

1. Enumerative search with grid resolutions of 0.1, 0.01, and 0.001.
2. Random Search with five different numbers of points, the specific number to be chosen by the student.
   - Describe the effect the number of sample points had on the quality of the solution.
3. Hill climbing method. Use three different neighborhood sizes to be selected by the student.
   - Sample 20 points randomly from the neighborhood during neighborhood search.
   - Select a reasonable number for MAX_ITERATIONS.

For each of the above methods each student is required to create an original computer program in a language of their choosing (C++/C, Fortran, Matlab, Visual Basic, etc.). The code should be commented so that it can be easily understood. Results should include tables and graphs where appropriate and include a discussion of the quality of solutions found by each method as well as their efficiency. Keep the discussion concise and short! The entire assignment excluding the code should not be more than 3-4 pages long. It should be completed in Word or some other word processing program.

<u>Answer:</u>

The optimal solution lies at –(.0898, .7126) where the value of f(x) is –1.03

The grading for this question is not on the basis of how close to the optimal you have come.