IE 607 Heuristic Optimization

Miscellaneous Methods - I

Scatter Search

- F. Glover (1977), “Heuristic for integer programming using surrogate constraints,” *Decision Sciences*, 8(1), 156-166.
- Main Idea: evolutionary, population-based search that uses linear combinations of existing solutions

Scatter Search Procedure

1. Generate a set, of size N, feasible solutions (Diversification Generation Method + Improvement Method)
2. Evaluate the solutions and designate E of them as elite where E < N (Reference Set Update Method)
3. Randomly choose R (two or more) from E for recombination where R << E (Subset Generation Method)

Scatter Search Procedure (cont.)

4. Recombine the solutions to create a new solution, and repair if necessary to be feasible (Solution Combination Method)
5. Local search to improve the new feasible solution
6. Add the new solution if it is better than the worst solution in the set
7. Loop to step 3, and continue until termination criteria are met

- **Diversification Generation Method**

  generate a collection of divers trial solutions, using an arbitrary trial solution as an input

- **Improvement Method**

  transform a trial solution into one or more enhanced trial solutions

- **Reference Set Update Method**

  build and maintain a reference set consisting of the b best solutions found

- **Subset Generation Method**

  operate on the reference set ad produce a subset of its solutions as a basis for creating combined solutions

- **Solution Combination Method**

  transform a given subset of solutions produced by the subset generation method into one or more combined solution vectors

Greedy Randomized Adaptive Search Procedue (GRASP)

- T. Feo an M. Resende (1995), “Greedy randomized adaptive search procedures,” *Journal of Global Optimization*, 16, 109-133.
- Main Idea: iterative, single solution search procedure using two phases, a construction phase followed by an improvement phase

GRASP Procedure

1. Use a randomized, greedy heuristic, construct an initial solution (Construction phase)
2. Apply local search to this constructed solution and move to best solution in the neighborhood (Improvement phase)
3. Record this solution, and loop to step 1, until termination criteria are met

- **Construction phase**

  A feasible solution is built one element at a time. The element is selected randomly from a candidate list which is sorted by a greedy function.

  →diversification to explore the solution space & produces good starting solutions for next phase

- **Improvement phase**

  successively replace the current solution by a better one from its neighborhood

Variations on Simulated Annealing

- G. Dueck (1993), “New optimization heuristics,” *Journal of Computational Physics*, 104, 86-92.
- Main Idea: deterministic, single solution heuristics that use the notion of sometimes taking non-improving moves but reduce the number of tunable parameters

Threshold Accepting (TA)

Procedure (Max E):

1. Select an initial solution
2. Choose an initial threshold, T, > 0
3. Generate a neighboring solution, and compute $\triangle E$ (= E_{new} - E_{old})

   if $\triangle E > -T$, accept move
4. After no improvement for a long time, or many iterations, reduce T
5. Loop to step 3, until termination criteria are met

Great Deluge Algorithm (GDA)

Procedure (Max E):

1. Select an initial solution
2. Choose the “rain speed” UP > 0
3. Choose an initial “water level” WL > 0
4. Generate a neighboring solution, and compute E_{new}
   if E_{new} > WL, accept move
5. WL = WL + UP
6. Loop to step 4, until termination criteria are met

Record to Record Travel (RRT)

Procedure (Max E):

1. Select an initial solution and set its E = Record
2. Choose an allowed Deviation, D, > 0
3. Generate a neighboring solution, and compute E_{new}

   if E_{new} > Record - D, accept move

   if E_{new} > Record, then Record = E_{new}
4. Loop to step 3, until termination criteria are met

Advantages of TA, GDA & RRT

- Depend only on one single parameter
  →threshold(T) in TA
  rain speed(UP) in GDA
  allowed deviation(D) in RRT
  →large T, small UP, & large D produce better results in long run