Heuristic Methods

Heuristic methods provide general and efficient ways to search for good but not necessary optimal solution.

Simulated Annealing

- annealing: a metallurgical technique that uses a disciplined cooling schedule to efficiently bring the steel to a low-energy, optimal state
- In thermodynamic theory, the energy state of a system is described by the energy state of each of the particles constituting it. The energy state of each particle jumps about randomly governed by the temperature of the system. The probability of transition from energy $e_i$ to $e_j$ at temperature $T$ is given by: $P(e_i,e_j,T) = e^{(e_i-e_j)/(kT)}$, where $k$ is the Boltzmann’s constant.
- The probability of moving from a high-energy state to a lower-energy state is very high. However, there is also a nonzero probability of accepting a transition into a high-energy state, with small energy jumps much more likely than big ones. The higher the temperature, the more likely such energy jumps will occur.
- To find optimal solution by simulated annealing, the cooling down process has to be very slow.
- The simulated annealing solution works admirably, considering it uses very little knowledge about the problem.
- Traveling salesman problem: swap two edges on the tour with two others that replace it.
- Maximum cut problem: select on vertex at random and move it across the partition.
- Maximum independent set problem: add or delete one vertex from set.
- Circuit board placement problem: minimizing the area of aspect ratio of the board, the total or longest wire length in connecting the components, the crossing of wires. move rectangle, swap the position of two rectangles, etc.
- Local and global optimization: local optimization using Simplex methods, or gradient approach. Global optimization using simulated annealing.

Neural Networks

- The basic computational component of the brain is a neuron, a simple unit that produces a nonlinear, weighted sum of its inputs, which are connections from other neurons. Learning in brains seems to work by adding connections between different pairs of neurons and changing the strengths of the connections.
- Neural networks have been more successful in classification, forecasting, and pattern-recognition applications.

Genetic Algorithms

- Genetic algorithms maintain a population of solution candidates for the given problem. Elements are drawn at random from this population and allowed to reproduce, by combining some aspects of the two parent solutions. Eventually, unfit elements die from the population, and is replaced by successful-solution offspring.
- It is quite unnatural to model most applications in terms of genetic algorithms, and it takes a very long time on nontrivial problems.