GRASP

GRASP = Greedy Randomized Adaptive Search Procedure.

Heuristics for finding good local minima.

One method to find a good local minimum is to:

- generate a random solution
- use local search to move from this random solution to a local minimum
- repeat

GRASP modifies this by trying to make the generated random solution reasonably good:

- Use a slightly randomized modified greedy algorithm to generate an initial solution
- Use local search to move from this initial solution to a local minimum
- Repeat

E.g.: Set cover: \[ \min x_1 + x_2 + x_3 + x_4 \]

\[ \text{s.t.} \quad \begin{align*}
    x_1 + x_2 & \geq 1 \\
    x_1 + x_3 & \geq 1 \\
    x_1 + x_4 & \geq 1 \\
    x_2 + x_3 & \geq 1 \\
    x_3 & \geq 1 \\
    x_4 & \geq 1 \\
    x_i & \text{ binary}
\end{align*} \]
Greedy approach: Satisfy as many constraints as possible.
So set \( x_1 = 1 \) initially.
Then need \( x_2 = x_3 = x_4 = 1 < 150 \).

**GA/SA:**
\[ x_{1} \]
1 satisfies 3 constraints
\[ x_{2} = 1 \] or \[ x_{3} = 1 \] or \[ x_{4} = 1 \] and satisfies 2 constraints.

If 2 is close enough to 3 in our selection procedure, pick any of the four variables on the first step. May then be able to generate \( x_1 = 0, x_2 = x_3 = x_4 = 1 \) in initial phase.

So:
Don't necessarily pick the best or most greedy move.
Instead: pick a move that leads to reasonably close to the next greedy move.

Advantages:
1. Compared with greedy, GA/SA visit more of the feasible region.
2. Compared with random initialization:
   1. Random initialization generates some very bad solutions. It takes a long time to make one of these solutions look reasonable. So GA/SA can look at more solutions than random initialization in the same amount of time.
   2. GA/SA is like intensification and tabu search: We concentrate on the part of the feasible region which is likely to contain the optimal solution, and many good solutions.

Disadvantages:
May not visit the part of the feasible region containing the optimal solution. Can use diversification to try to overcome this.
Applications include:
- Set covering
- Node packing
- Quadratic Assignment
- Facility location problems
- Production planning
- Scheduling
Eg: TSL:

Have a collection of jaws.

Pick two of the front.

Check for repair.

Eg: Crowe.

Other words in the order.

Eg: 3.

Check for repair.

Eg: 3.

Check for repair.

Try preparing a model of the tooth.

Try preparing a model of the tooth.

Eg: 3.

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Eg: 3.
So, perhaps, get the tour:
1 → 4 → 2 → 3 → 5 → 6 → 8 → 7 → 1

AetNA

Again many possibilities.

One choice: with low probability, move one city to a different place in the tour.

Can also delete tours with very small population reasonable.

Widely used.

Eg: TSP
Vehicle routing
Assignment problem
VLSI Component placement
Job Shop Scheduling
Database query optimization
Satisfiability.