Stochastic Optimization - 2

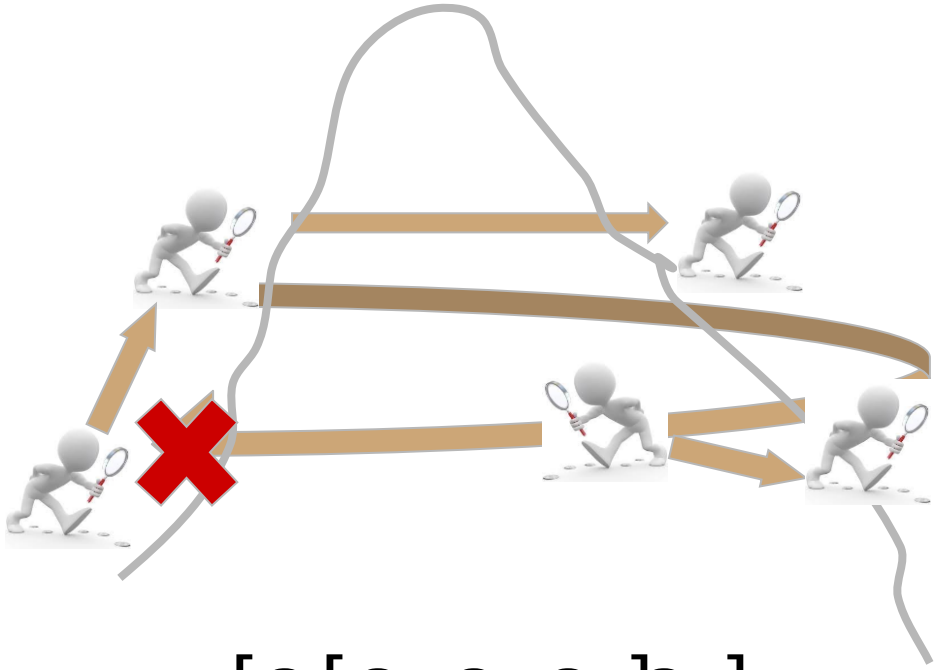
Taboo Search

Taboo Search

Taboo Search

- Proposed by Fred Glover (1986) and Hansen (1986);
- Single agent algorithm, adapted to discrete problems;
- "Taboo" because it is forbidden to return to a solution recently visited;
- Using a short-term memory of solutions already visited to avoid loops;
- Local search in the neighborhood of a solution. Problem when this neighborhood is important: need to sample a subset of neighbors.

Taboo Search - Illustration



$[\, s_1 [\, s_2; s_3; s_4;] s_5 \,]$

Taboo Search - Principle

- The current solution is replaced by its best neighbor that is not in the taboo list;
- The best neighbor can degrade the current solution;
- The taboo list prevents re-selecting an already visited neighbor (cycle pb);
- The size is limited: forgotten solutions visited.

Algorithm of Taboo Search

```
X, a solution, f(X) its evaluation
f_min <- f(X)
X_min <- X
lTabou <- emptyList
While not convergenceCriterion()
     X_vois <- getBestValidNeighbor(X,lTabou)
     if f_min < f(X_vois) then
          f_min <- f(X_vois)
          X_min <- X_vois
      end if
     f(X) <- f(X_vois)
     X <- X_vois
     lTabou <- updateTabouList(lTabou,X)
end of while
```

Tabou Search - Convergence Criteria

Allows you to complete the algorithm according to several conditions:

- The number of evaluations reaches a limit;
- There has been no improvement since a number of iterations.

Taboo Search - Short Term Memory

Allows to not "go back" to a previous solution:

- FIFO structure containing n "taboo" positions;
- The length of the list is a critical parameter:
  - *n large: promotes exploration, avoids cycles, can "miss" an optimal value*;
  - *n small: promotes exploitation, allows the appearance of cycles;*
- Self-adaptive parameter;

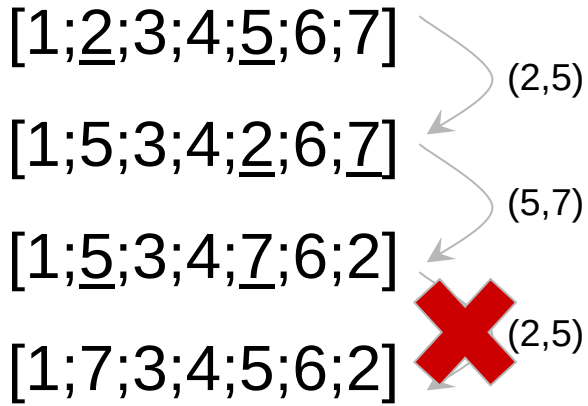
Taboo Search - Short Term Memory

2 save strategies:

- the solutions visited are stored (according to the size of the problem, gourmand in memory and comparisons);
- we store forbidden movements (lighter, eliminates more solutions than the previous ones).

Taboo Search - Short Term Memory

Example of saving movements: TSP problem:



List of taboo movements:

[(2,5);(5,7)]

The solution [1; 7; 3; 4; 5; 6; 2], although not visited, is not feasible. Need to relax this constraint: **aspiration criterion.**

Taboo Search - Aspiration Criteria

Storing prohibited moves prevents the generation of good unexplored solutions.

Skip this prohibition under certain constraints, for example:

- The solution generated by the movement improves the best solution;
- The evaluation of the solution generated was not given by the last n movements

Taboo Search - Disturbance

Same problem as simulated annealing;

- Generates a new solution in the **neighborhood** of the current solution;
- Influence of the distance between these two solutions (hypervolume of the neighborhood);
- Specific to the problem to be solved (discrete / continuous).

Search Tabou - Neighborhood

- Set of local transformations applied to a solution;
- According to the size or type of the problem, it can be very large;
- Problem of random sampling of the set: "miss" the optimal solution.

Search Tabou - Neighborhood

Two strategies:

- Visit all the neighborhood is (restrictive or impossible);
- Visit until improving or we arrive at a limit number;
- Generate only "promising" neighbors, requires the calculation of the efficiency a movement;

Taboo Search - Medium / Long Term Memory

Improve performance by adjusting the balance of exploration and exploitation.

- **Diversification** : explore areas of the search space with little or no solicitation;
- **Intensification** : periodically return to promising research areas or replay interesting moves ;

=> Exploration remains important because of the difficulty of getting out of a local optimum.

Taboo search - Medium term: intensification

Concentrate research around good solutions or involve movements with high potential for improvement.

- Save:
  - Good solutions to intensify research around them (exploitation);
  - The frequency of realization of a movement;
  - The frequency of appearance of an attribute of the solution;
- Freeze certain attributes, prohibit certain movements so as not to deviate from a good solution;
- Penalize the evaluation of distant individuals (or vice versa).

Taboo Search - Long term: diversification

Play unrealized moves to explore new areas of the research space (exploration):

- Rebuild a solution by using movements / attributes that are little or not used;
- Penalize the evaluation of close individuals (or vice versa).

That’s all folks !