Lecture02b: Local Search II

CS540 1/25/18

Announcements

On-campus students:

You should have access to Canvas now (re-check)

First reading assignment: R. Qu, et. al. *A Survey of Methodologies and Automated System Development for Examination Timetabling,* Journal of Scheduling, 12(1):55-89.

2nd reading assignment: M. Contreras-Cruz, V. Ayala-Ramirez, and U. Hernandez-Belmonte. *Mobile robot path planning using artificial bee colony and evolutionary programming.* Applied Soft Computing 30(2015):319-328

Local Search (General Idea)

Goal: find a termination state

- Example: SAT (find a mapping of variables to {T,F})
- Counter-example: Path planning (output is a sequence of states)

Method

- Start with an initial state
- On every step:
  - Evaluate "neighboring" states (small variations of current state)
  - Move to neighboring state with better evaluation score
- Variations on strategy
  - First improvement
  - Steepest ascent
- Variations on evaluation
  - Evaluation function is the function to be optimized
  - Evaluation function is a cheaper heuristic.

Constraints

- Finite memory
- Classic form: "memory-less"
- Modifications: finite (but non-zero) memory

Adding Memory

Add just one state of memory ("best so far")

Random Restart Local Search

- Run local search from random start position
- Save result as "best so far"
- Run local search N more times
- After each, if result is better than "best so far", replace

Note: any local search strategy will do

- Generally run lots of fast searches

Adding N States

Parallel Local Search

- Run N searches in parallel
- Compares N local optima, select best
- Similar to random restart

Beam Local Search

- Initialize with N random states
- Compute N neighborhoods
- Select N best elements from combined neighborhoods
- Repeat

Various heuristic additions to beam search…

Unlimited Memory

Tabu Search (Glover 1986)

Basic idea:

- Keep memory of visited states (tabu table)
- Do not return to tabu states

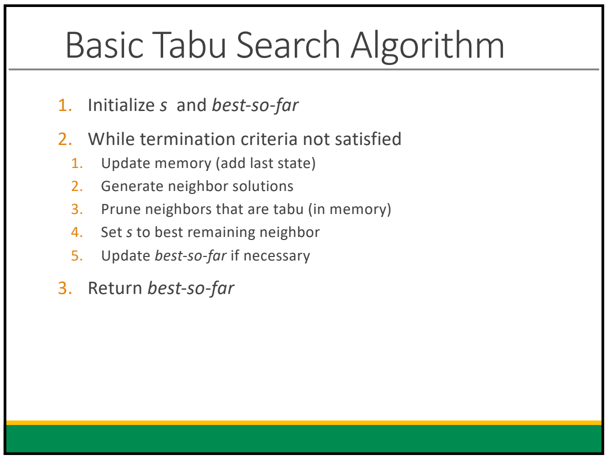
Deterministic search

- Never return to visited state

Stochastic search

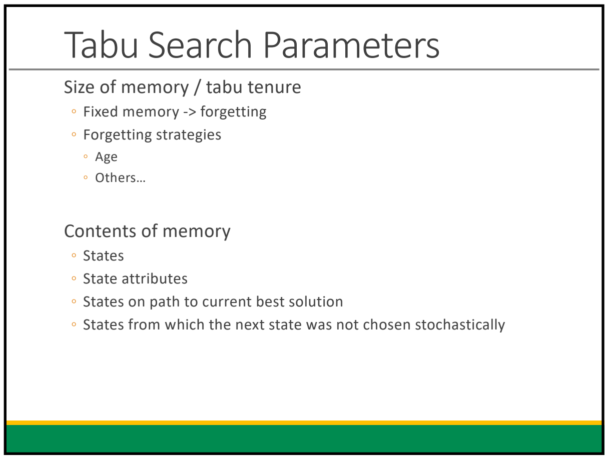
- May be value to returning to visited state
- But odds of improvement are less

Issue: Memory size



Basic Tabu Search Algorithm

1. Initialize *s* and *best-so-far*
2. While termination criteria not satisfied
   1. Update memory (add last state)
   2. Generate neighbor solutions
   3. Prune neighbors that are tabu (in memory)
   4. Set *s* to best remaining neighbor
   5. Update *best-so-far* if necessary
3. Return *best-so-far*



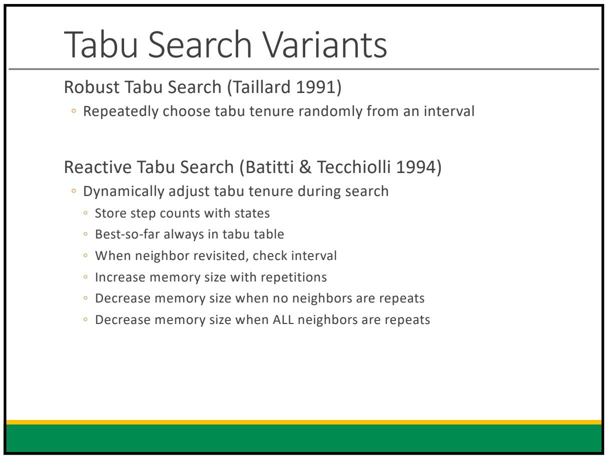
Tabu Search Parameters

Size of memory / tabu tenure

- Fixed memory -> forgetting
- Forgetting strategies
  - Age
  - Others…

Contents of memory

- States
- State attributes
- States on path to current best solution
- States from which the next state was not chosen stochastically



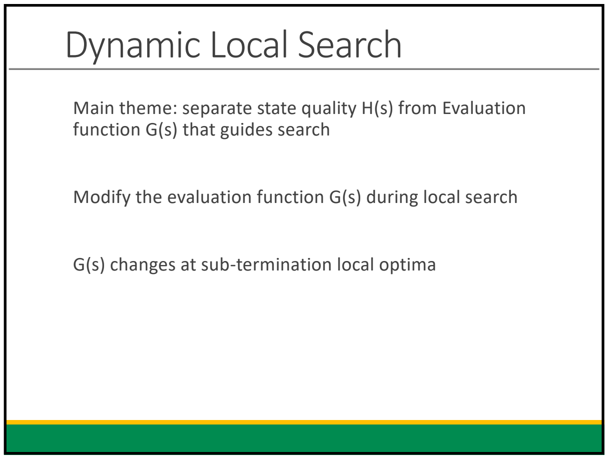
Tabu Search Variants

Robust Tabu Search (Taillard 1991)

- Repeatedly choose tabu tenure randomly from an interval

Reactive Tabu Search (Batitti & Tecchiolli 1994)

- Dynamically adjust tabu tenure during search
  - Store step counts with states
  - Best-so-far always in tabu table
  - When neighbor revisited, check interval
  - Increase memory size with repetitions
  - Decrease memory size when no neighbors are repeats
  - Decrease memory size when ALL neighbors are repeats

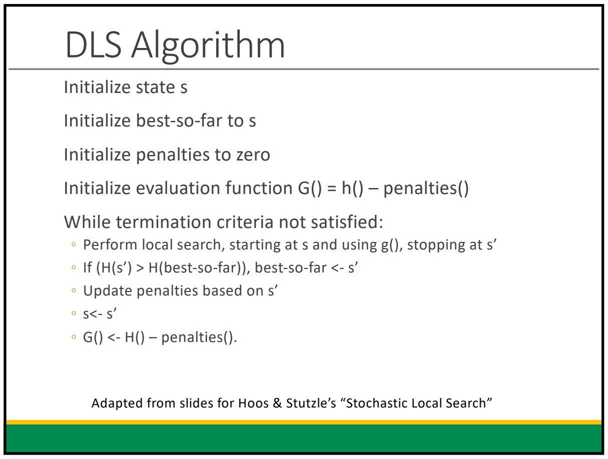


Dynamic Local Search

Main theme: separate state quality H(s) from Evaluation function G(s) that guides search

Modify the evaluation function G(s) during local search

G(s) changes at sub-termination local optima



DLS Algorithm

Initialize state s

Initialize best-so-far to s

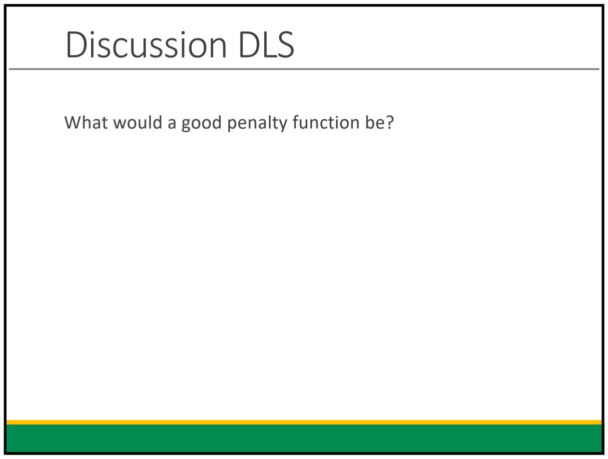
Initialize penalties to zero

Initialize evaluation function G() = h() – penalties()

While termination criteria not satisfied:

- Perform local search, starting at s and using g(), stopping at s’
- If (H(s’) > H(best-so-far)), best-so-far <- s’
- Update penalties based on s’
- s<- s’
- G() <- H() – penalties().

Adapted from slides for Hoos & Stutzle’s “Stochastic Local Search”



Discussion DLS

What would a good penalty function be?