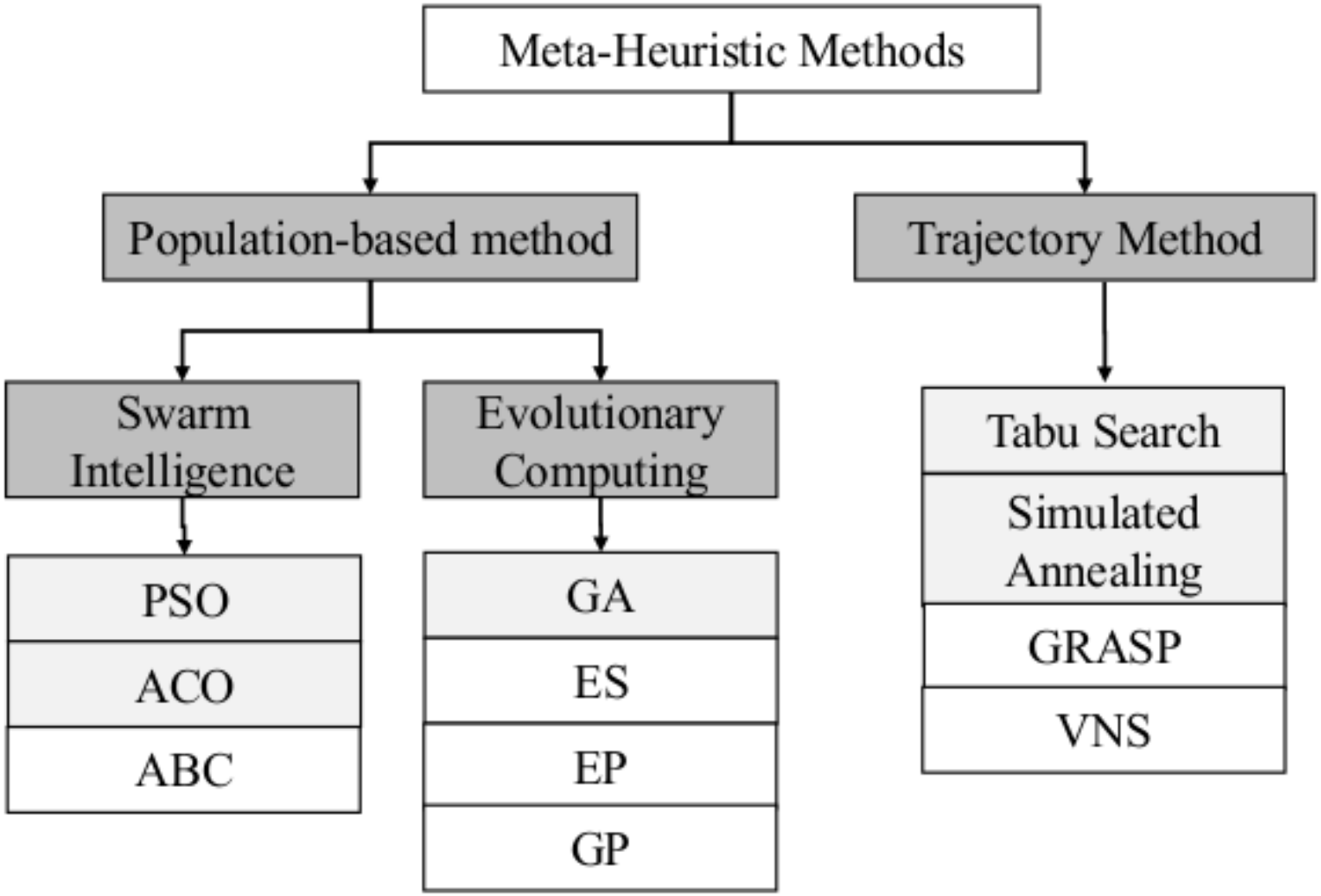
Revision Lecture



Revision Lecture - Q1

(a) What is the difference between strong and weak methods?

(b) What are the properties of search algorithms?

(c) What is the difference between informed and uninformed search? List some algorithms for each.

(d) What are the types of heuristics?

(e) What are the types of game playing?

(f) Write the pseudo code for Tabu Search, what are the components of Tabu Search and what does each do?

Max Min strategy:

- Common in zero sum games
- Minimax principle: when in conflict minimize the maximum losses
- Expand the game tree by N levels then evaluate using minimax principle in a depth first search manner

Alpha Beta Pruning:

- Branch and bound idea
- Alpha Cutoff, Beta Cutoff
- Bread first search manner

```
# Tabu Search Pseudo Code
Generate an initial solution

While termination criterion not met:
    Choose the best:
    s' in N(s) = {N(s) - T(s)} + A(s)

    if s' is better than s:
        s = s'
    Update T(s) and A(s)

where:
    N(s): neighborhood function
    T(s): tabu list
    A(s): aspiration list
```

Revision Lecture - Q1f

Tabu Search Components:

- **Candidate List**: helps address some of the search space issues
- **Tabu List**: acts as memory to avoid revisting
- **Aspiration List**: useful to allow a certain move even it is tabu

Revision Tip: Search Comparisons

Algorithm	Complete	Optimal	Time Complexity	Space Complexity
Breadth-First Search	Yes	Yes	b^d	b^d
Uniform-Cost Search	Yes	Yes	b^d	b^d
Depth-First Search	No	No	b^m	bm
Depth-Limited Search	Yes, if l >= d	No	b^l	bl
Iterative Deepening	Yes	Yes	b^d	bd
Greedy BFS	No	No	b^m	b^m
Beam Search	No	No	ßb	ßb
A* Search	Yes	No	b^d	b^d
Hill Climbing (no back)	No	No	d	b
α-β pruning	Yes	No	$b^{d/2}$ - b^d	b^d

Revision Lecture - Q2

(a) Explain the rationale behind Simulated Annealing, what is it trying to mimick?

(b) Write pseudo code for simulated annealing

(c) During high temperatures how does Simulate Annealing traverse the search space? What about low temperatures? (i.e. what algorithms does SA behave like during high and low temperatures?)

Errors in Lecture Slides?

SA Basic Algorithm

- Set current solution to an initial solution s= s_0
- Set current temperature to an initial temperature $t = t_0$
- Select a temperature reduction function α
- Repeat
  - Repeat
    - Select a solution s_i from the neighborhood $N(s)$
    - Calculate change in cost according to the new solution ΔC
    - If ΔC <0 then accept new solution (it is improving) s= s_i
    - Else generate a random number x in the range (0,1)
      - If x < $e^{-\Delta c/t}$ then accept new solution s=s_i
  - Until max no. of iterations for the temperature
  - Decrease t using α
- Until stopping conditions are satisfied
- s is the final solution

ECE457A, Dr. Allaa Hilal, Spring 2017

Revision Tip: Termination Criterias are generally the same

- Number of iterations reached
- Satisfactory solution found
- Stale; Not improving
- Time limit reached

```
# Simulated Annealing Pseudo Code
Set current solution to initial solution s = s0
Set current temperature to initial temperature T = T0
Set Temperature reduction function alpha

while not terminate:
    select a solution s_i from neighborhood N(s)
    calculate change in cost dC

    if dC < 0:
        s = s_i
    else:
        generate random number x in (0, 1)
        if x < exp(-dC / T):
            s = s_i

    update temperature T
```

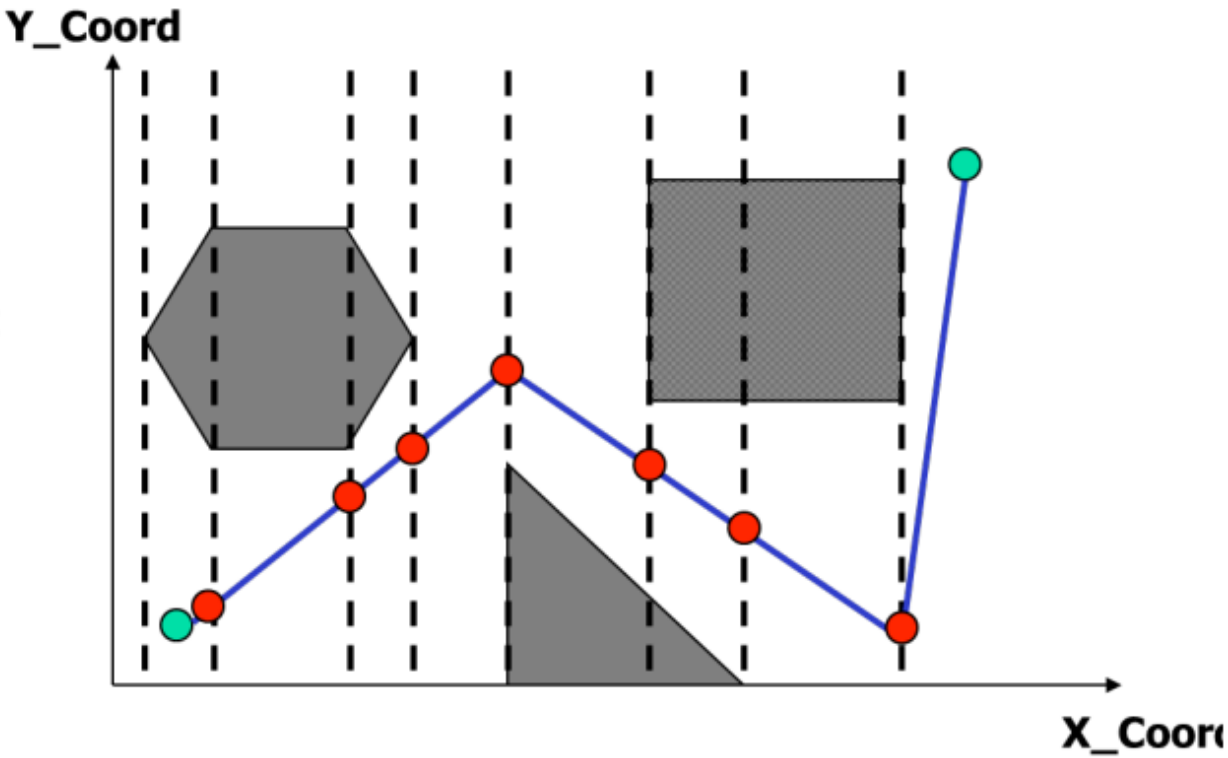
Revision Tips: How are they different?

For example how is Tabu Search, Simulated Annealing, Genetic Algorithm, Ant Colony Optimization, Particle Swarm different to each other?

One can use Hill Climbing as baseline to compare against.

Revision Lecture - Q2

The idea is to optimize the y-coordinates at which the path intersects with the vertical lines



Vertical lines are drawn at the obstacles vertices

Revision Tip: Almost all problems in the course can be represented as a list

For problems like TSP, Graph Coloring, Sudoku, Robot Motion planning taught in this course most of them can be represented as a list for Tabu Search, Simulated Annealing, Genetic Algorithm, Particle Swarm Optimization, Ant Colony Optimization to solve.

Revision Lecture - Q3

(a) What is the difference between phenotype and genotype?

(b) What are the general components / ingredients for a standard Genetic Algorithm?

(c) Write up the pseudo code for a genetic algorithm

(d) What is the advantages and disadvantage of using Fitness Proportionate Selection over Rank based Selection? How does Tournament selection compare to the former two? Answers should pay particular attention to how these selection affect the GA in traversing the search space.

Errors in Lecture Slides?

SGA – The algorithm

- Initialize population with random candidates,
- Evaluate all individuals,
- While *termination criteria* is not met
  - Select parents,
  - Apply crossover,
  - Mutate offspring,
  - Replace current generation,

  end while

```
# Genetic Algorithm Pseudo Code
Initialize population with random candidates
Evaluate individuals

While termination criteria not met:
    Select parents
    Apply crossover operator
    Apply mutation operator
    Replace current generation
    Evaluate individuals
```

Revision Lecture - Q3e

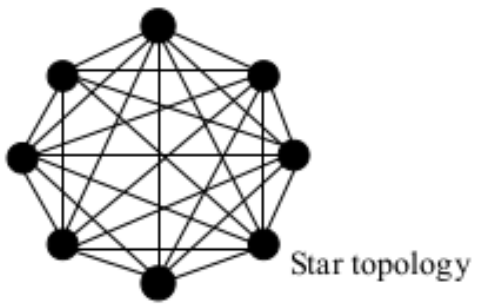
5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

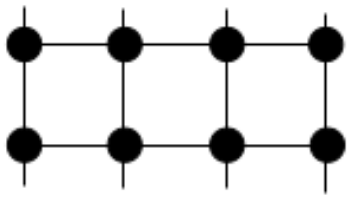
Revision Lecture - Q3e

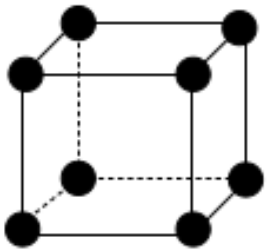
- Each horizontal row must contain the numbers 1-9, without repeating any
- Each vertical column must contain the numbers 1-9, without repeating any
- Each 3 x 3 block must contain the numbers 1-9, without repeating any.

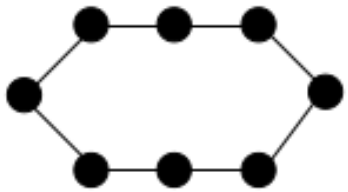
Revision Tip: Cooperative parts of Meta-heuristics

For SA, GA, ACO, PSO, most of these have a "cooperative part" they are mostly very similar, they share candidates some Star, Grid, Hyper Cube, Ring topology.


Star topology


Grid topology


Hyper-cube topology


Ring topology

Revision Tip: Adaptive parts of Meta-heuristics

GA, ACO, PSO they have **adaptive parameters schemes**, learn them!