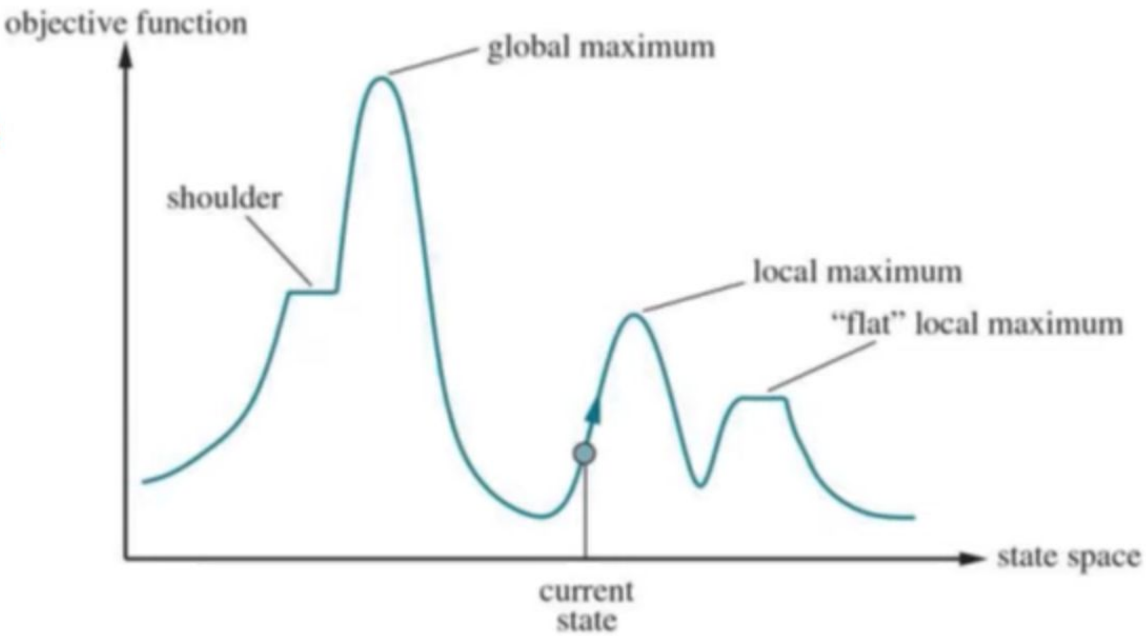
Search Techniques

SIMPLE HILL CLIBING SEARCH ALGORITHM

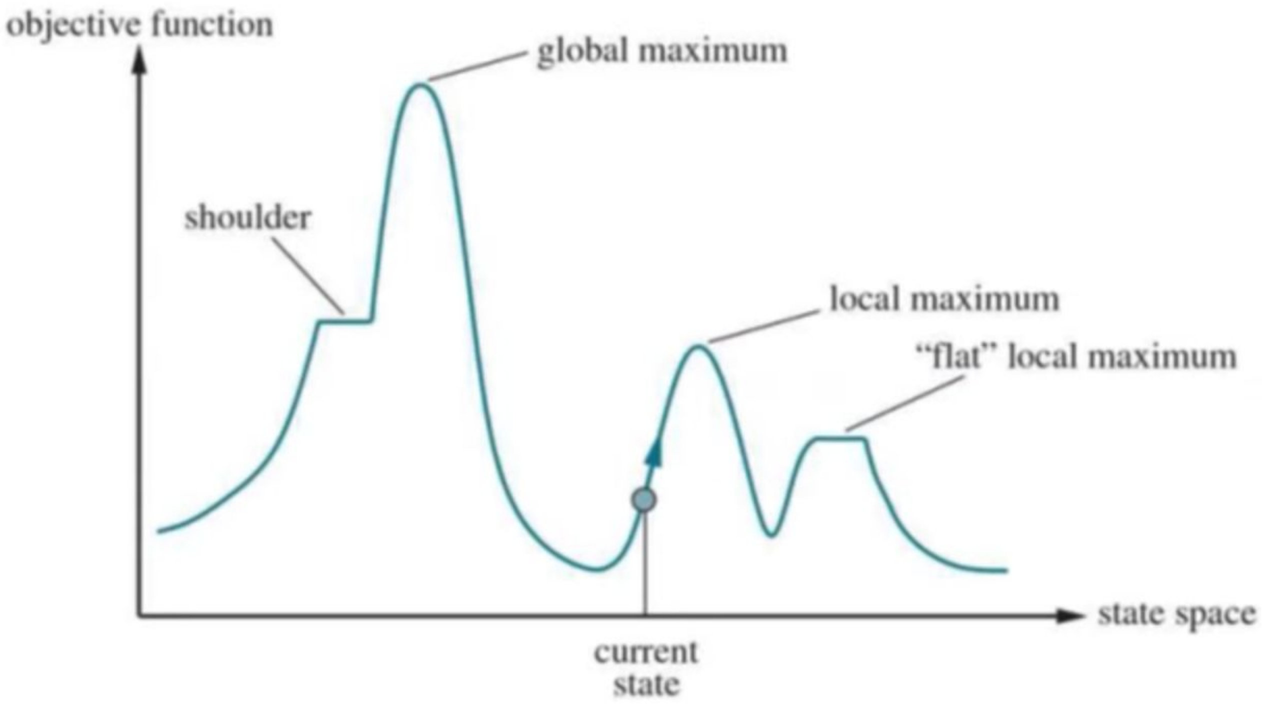
Hill-climbing Search Algorithm

- Hill climbing algorithm is a Heuristic search algorithm which continuously moves in the direction of increasing value to **find the peak of the mountain or best solution to the problem**.
- It keeps track of one current state and on each iteration moves to the neighboring state with highest value—that is, it heads in the direction that provides the **steepest ascent**.



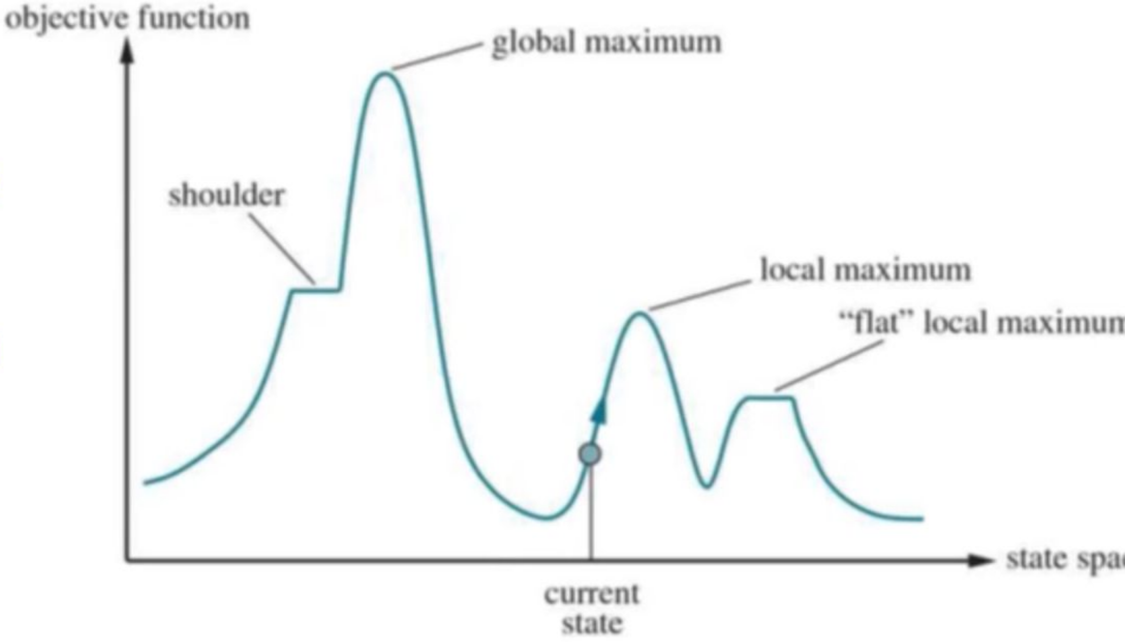
Hill-climbing Search Algorithm…

- In this algorithm, when it reaches a peak value where no neighbor has a higher value, then it terminates.
- It is also called greedy local search as it only searches its good immediate neighbor state and not beyond that.
- Hill Climbing is mostly used when a good heuristic is available.



Hill-climbing Search Algorithm

- Different regions in the state space landscape:
- **Local Maximum** is a state which is better than its neighbor states, but there is also another state which is higher than it.
- **Global Maximum** is the best possible state of state space landscape. It has the highest value of objective function.
- **Current state** is a state in a landscape diagram where an agent is currently present.
- **Flat local maximum** is a flat space in the landscape where all the neighbor states of current states have the same value.
- **Shoulder** is a plateau region which has an uphill edge.



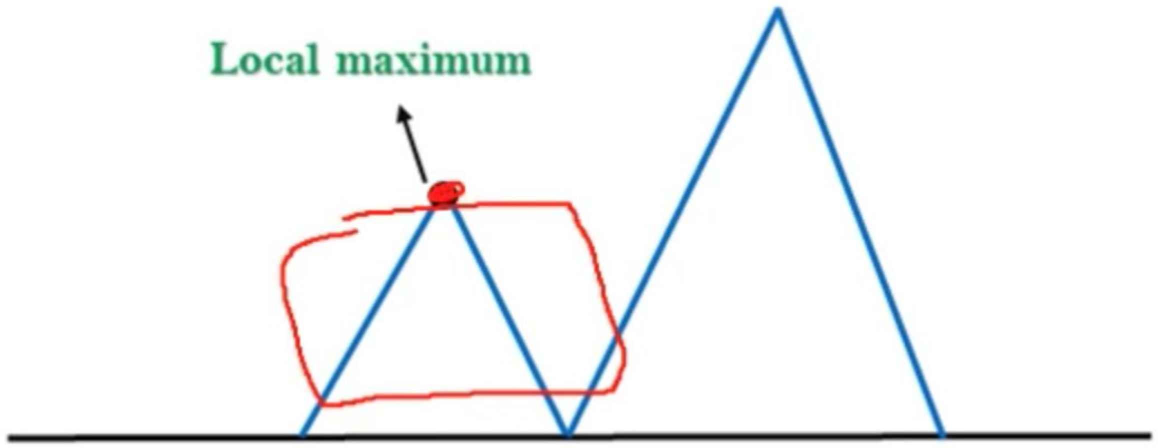
Hill-climbing Search Algorithm…

- The hill-climbing search algorithm, which is the most basic local search technique.
- At each step the current node is replaced by the best neighbor.

function HILL-CLIMBING(*problem*) **returns** a state that is a local maximum
    current ← *problem*.INITIAL
    while *true* **do**
        neighbor ← a highest-valued successor state of *current*
        if VALUE(*neighbor*) $\leq$ VALUE(*current*) **then return** *current*
        current ← *neighbor*

Problems in Hill Climbing Algorithm

- **1. Local Maximum:** A local maximum is a peak state in the landscape which is better than each of its neighboring states, but there is another state also present which is higher than the local maximum.
- **Solution:** Backtracking technique can be a solution of the local maximum in state space landscape.
- Create a list of the promising path so that the algorithm can backtrack the search space and explore other paths as well.



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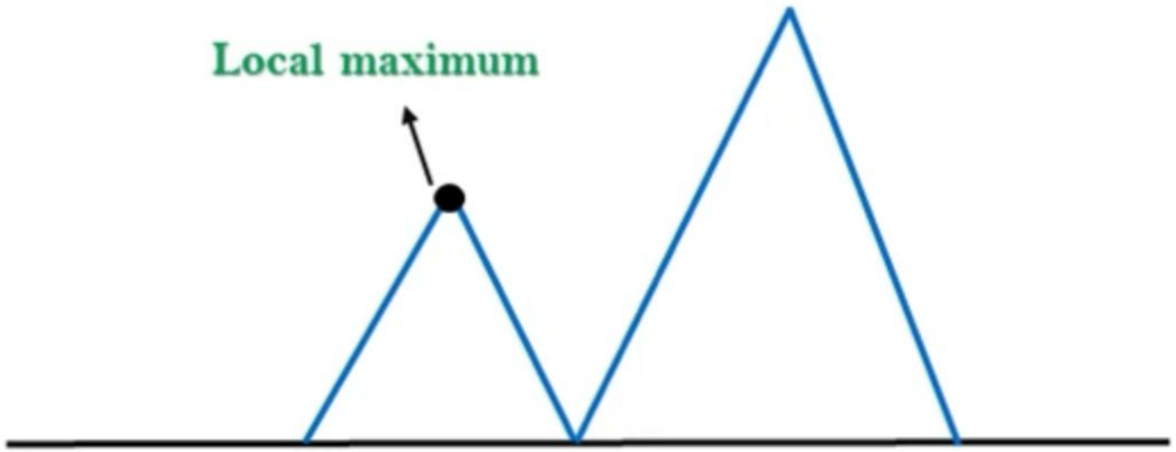
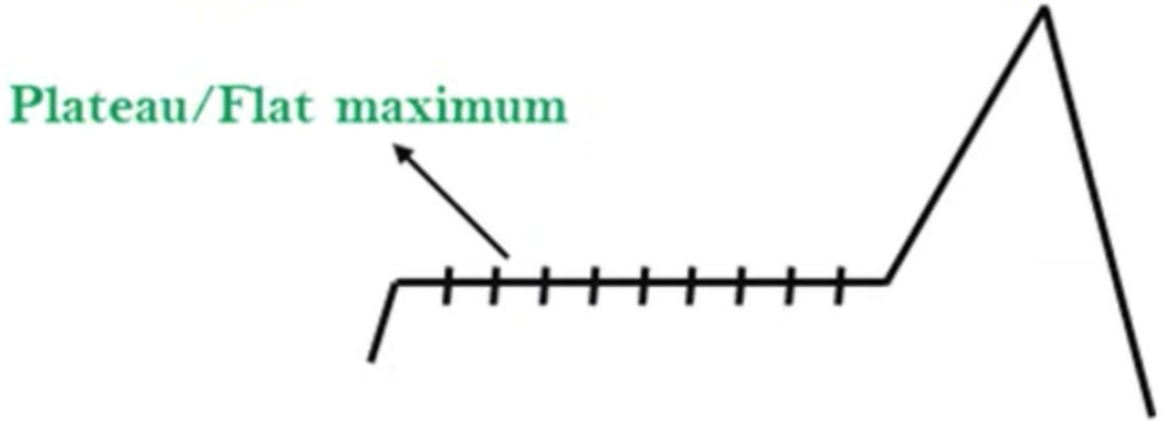


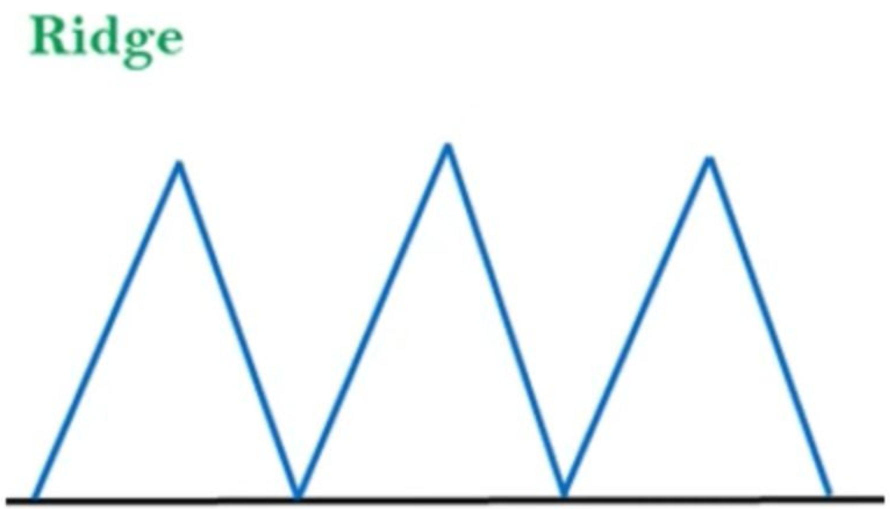
Problems in Hill Climbing Algorithm…

- **2. Plateau:** A plateau is the flat area of the search space in which all the neighbor states of the current state contains the same value, because of this algorithm does not find any best direction to move.
- A hill-climbing search might be lost in the plateau area.
- **Solution:** The solution for the plateau is to take big steps while searching, to solve the problem.
- Randomly select a state which is far away from the current state so it is possible that the algorithm could find non-plateau region.



Problems in Hill Climbing Algorithm…

- **3. Ridges:** A ridge is a special form of the local maximum.
- It has an area, which is higher than its surrounding areas, but itself has a slope, and cannot be reached in a single move.
- **Solution:** With the use of bidirectional search, or by moving in different directions, we can improve this problem.



Physical Annealing

- The Simulated Annealing algorithm is based upon Physical Annealing in real life.
- Physical Annealing is the process of heating up a material until it reaches an **annealing temperature** and then
- it will be **cooled down** slowly in order to change the material to a desired structure.
- When the material is hot, the molecular structure is weaker and is more susceptible to change.
- When the material cools down, the molecular structure is harder and is less susceptible to change.

Physical Annealing…

- Thermal Dynamics Equation calculates the probability that the Energy Magnitude will increase.

$$P(\Delta E) = e^{-\frac{\Delta E}{k*t}}$$

- Where ΔE - Energy Magnitude
- t - temperature
- k - Boltzmann constant.

Simulated Annealing

- **Simulated Annealing** is a stochastic global search optimization algorithm and it is modified version of stochastic hill climbing.
- This algorithm appropriate for nonlinear objective functions where other local search algorithms do not operate well.
- **The simulated-annealing solution is to start by shaking hard (i.e., at a high temperature) and**
- **then gradually reduce the intensity of the shaking (i.e., lower the temperature).**
- Simulated Annealing (SA) is very useful for situations where there are a lot of local minima.

Simulated Annealing - State Space Diagram

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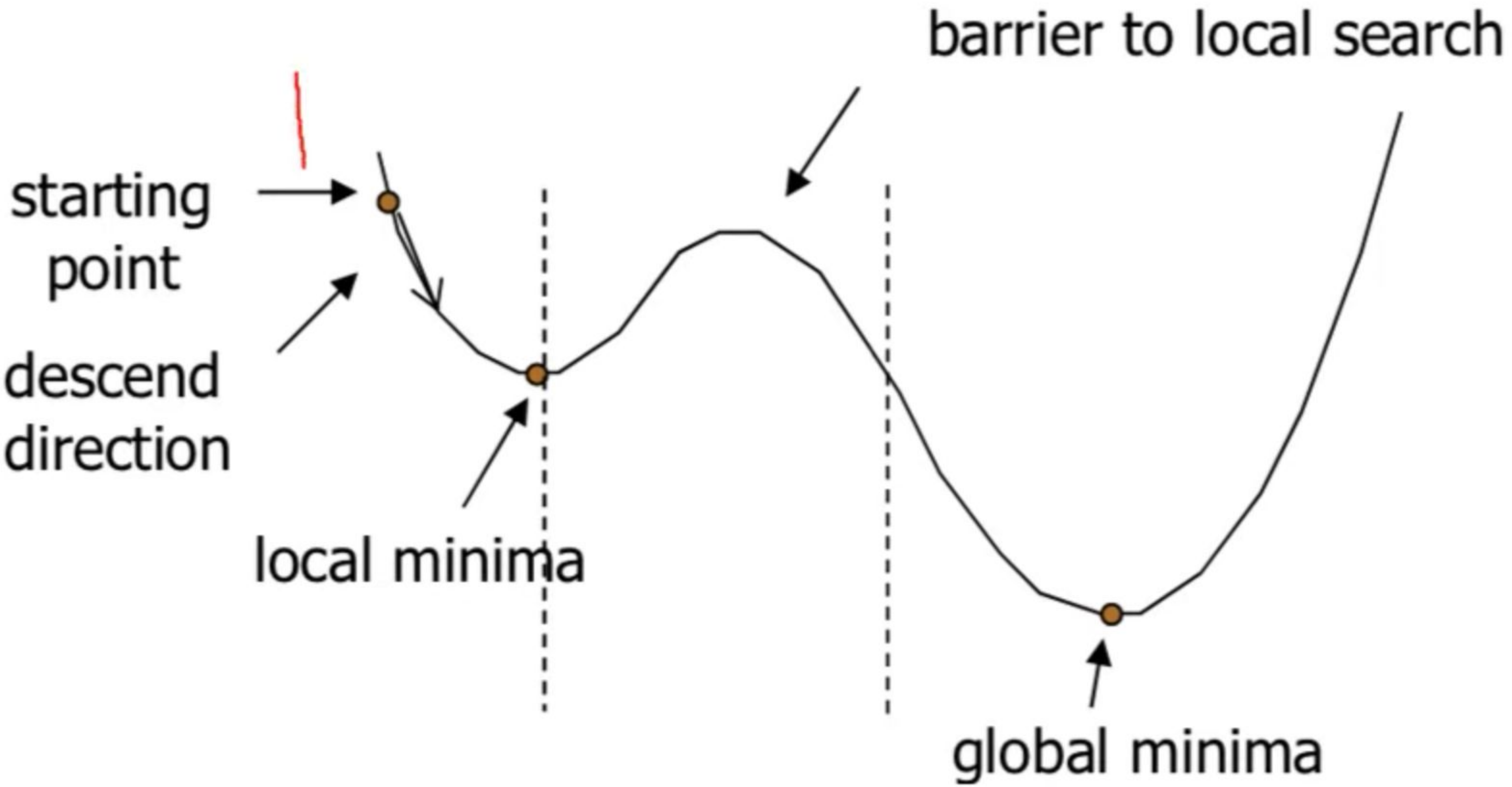
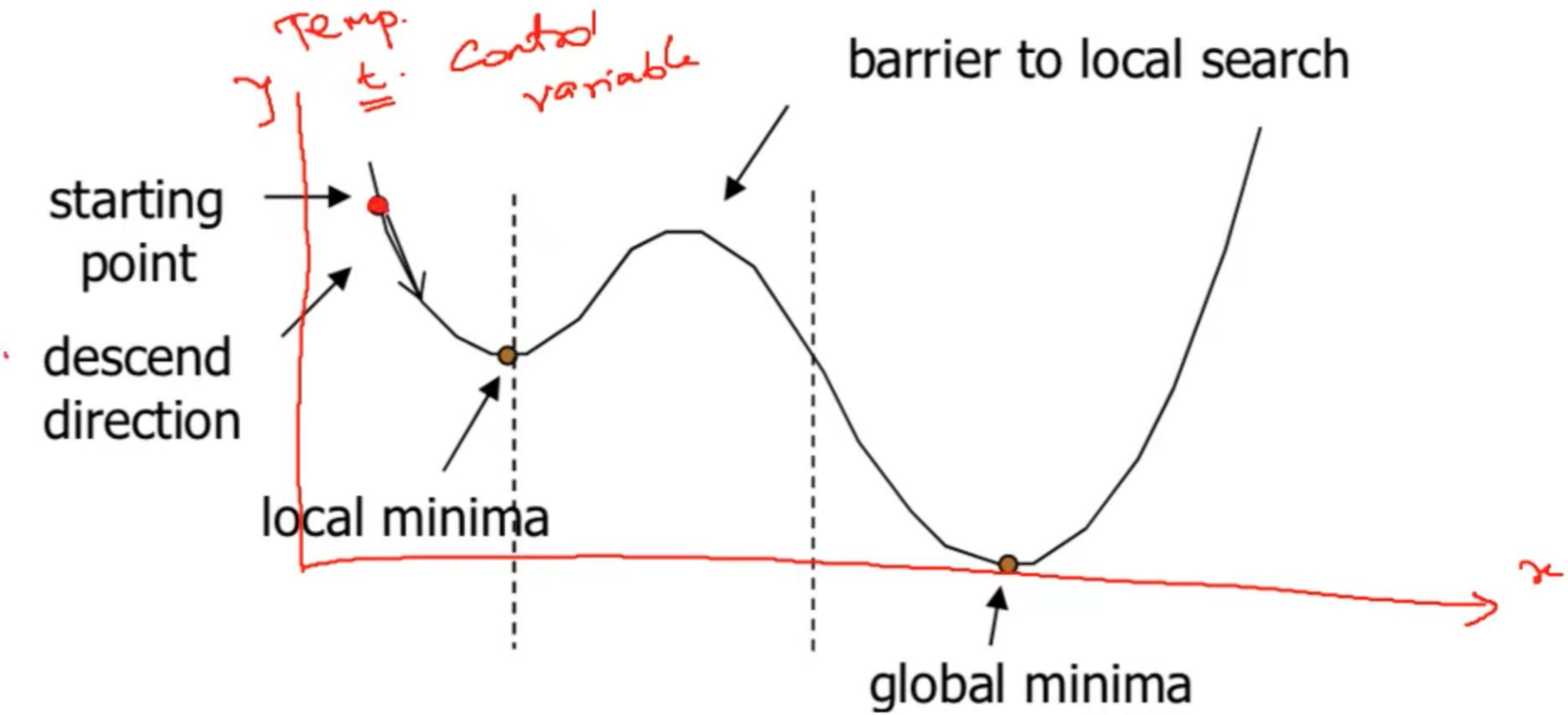


Simulated Annealing - State Space Diagram



Simulated Annealing - State Space Diagram

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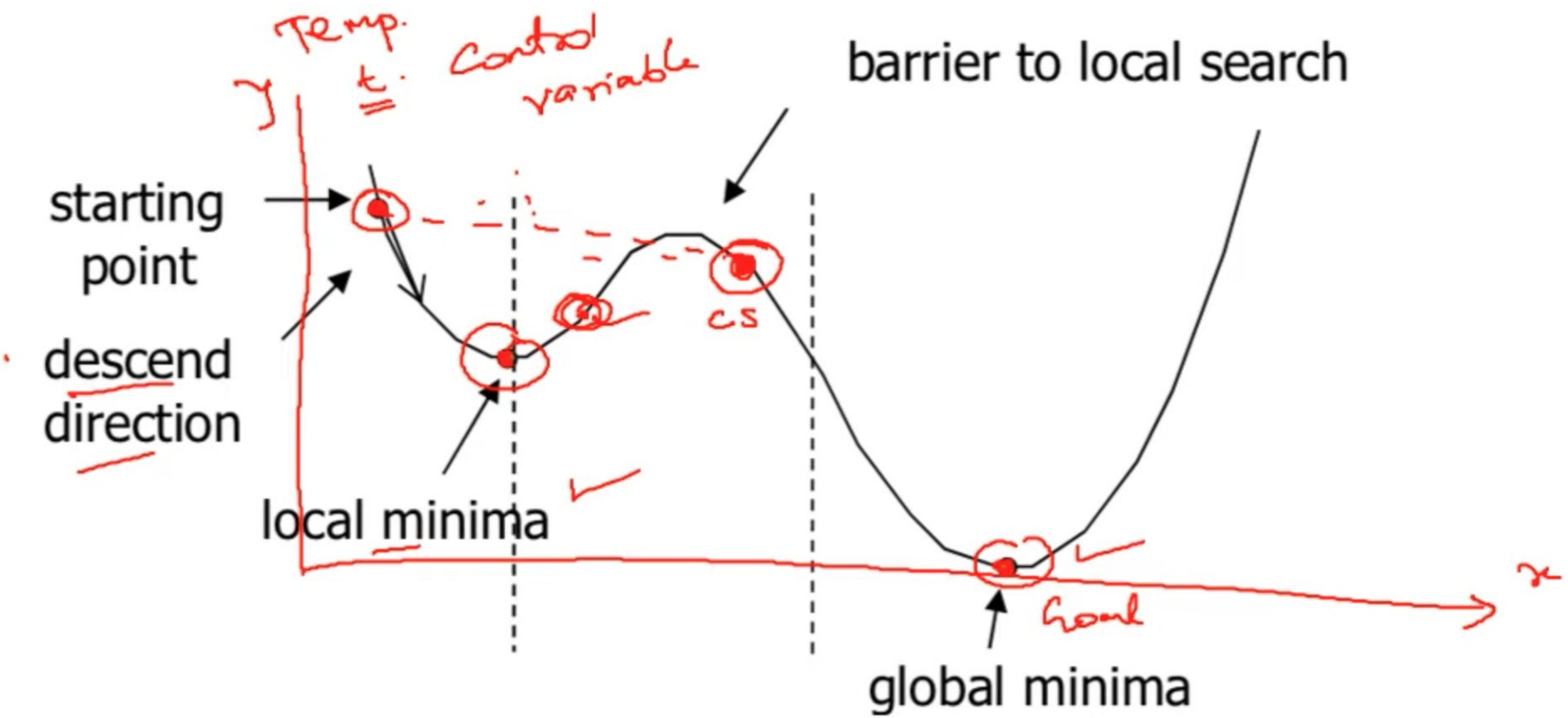
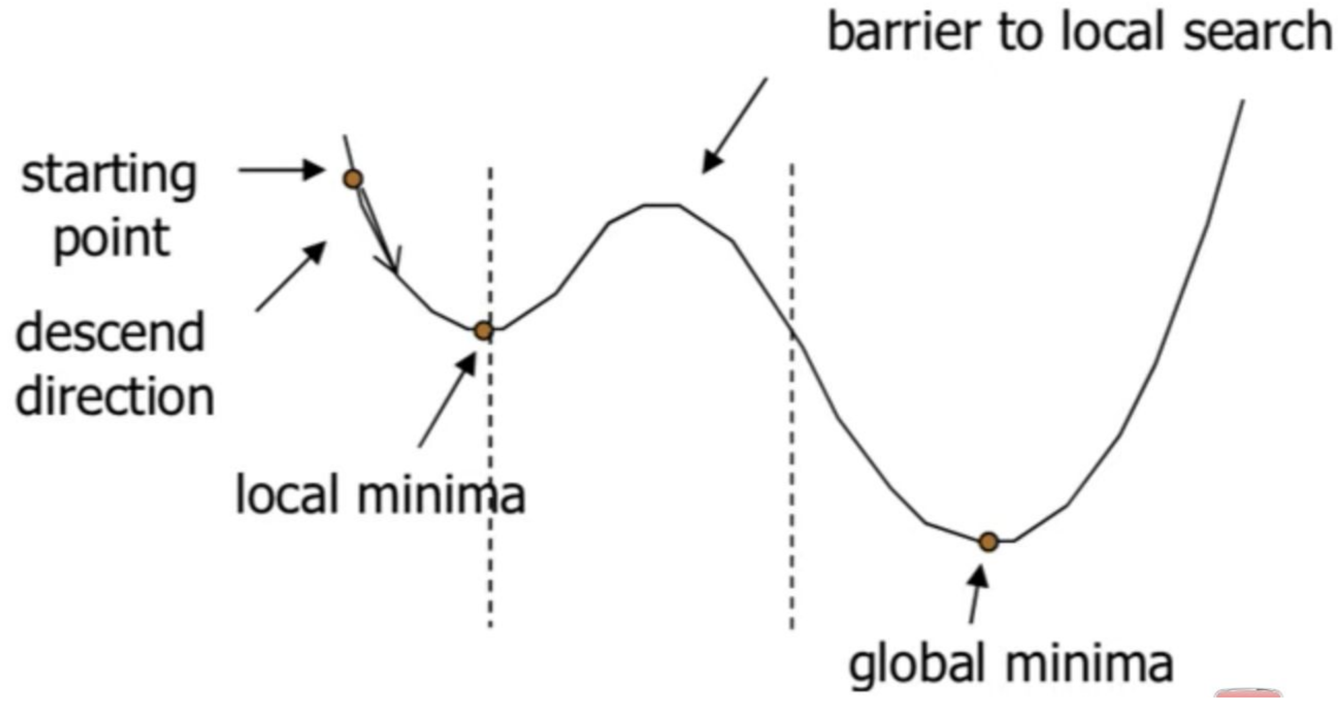


Simulated Annealing- Example- ping-pong ball

- Imagine the task of getting a ping-pong ball into the deepest crevice in a very bumpy surface.
- If we just let the ball roll, it will come to rest at a local minimum.
- The trick is to shake just **hard** enough, to bounce the ball out of local minima then the ball will reach the global minimum.



Simulated Annealing Algorithm

function SIMULATED-ANNEALING(*problem*, *schedule*) **returns** a solution state
  current ← *problem*.INITIAL
  for $t = 1$ **to** ∞ **do**
    $T \leftarrow$ *schedule*(t)
    if $T = 0$ **then return** *current*
    next ← a randomly selected successor of *current*
    $\Delta E \leftarrow$ VALUE(*current*) – VALUE(*next*)
    if $\Delta E > 0$ **then** *current* ← *next*
    else *current* ← *next* only with probability $e^{-\Delta E/T}$

Simulated annealing…

- Simulated annealing was used to solve VLSI layout problems
- It has been applied widely to factory scheduling and
- other large-scale optimization tasks.