* LAB-5 :

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* Simulated Annealing algorithm :-
- Algorithm
 1. Initialize the temperature and a random solution
 2. Evaluate the objective junction
   - This is to either minize or maxmize

 3. Generate a new solution in the neighborhood of the current solution
 - Modification can be done by adding or substracting a small random value from the current solution. This ensure that the new solution is closer to the current one.

4. compare the new solution to current one
 a. if the new solution is better, accept it
 b. if the new solution is worse, accept it with certain probability.

the acceptance probability is given by $p = e^{-\Delta f / T}$

Δf = (new sol) - (cure sol)

T = current temp.

5. Gradually lower the temperature - This process is known as cooling and it ensure that over time, the algorithm becomes more selective about which solutions to accept.

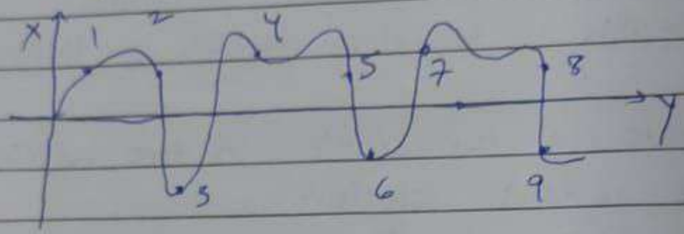
6. Repeat until the system reaches a stopping criterion.

- if the temperature has reached a predefined thre-shold.

- Maximum iterations has been reached.

- change in the objective function is too small or almost negligible

* Example:



Pseudocode

```
  func obj(x)
    return x^2
      END Func
  Func sa (sit, e, m)
      SET cs = s
      SET bs = cs
      SET bs = obj(cs)
      For i from 1 to M DO
        SET ns = cs + Random (-1,1)
        SET nc = obj(ns)
        SET cd = nc - bc
IF cd<0 OR Random (0,1) <
                  Exp(-cd/t)
    SET cs = ns
    SET bs = cs IF nc<bc
      END IF
      SET t = t* e
   PRINT i, cs, bc, t
      END FOR
     RETURN bs, bc
      END Func
```

```
BEGIN
    READ s, t, c, M
If = c<=0 OR c>=, THEN
    PRINT "Invallid, wcling raln"
        EXIT
    END If
    bs, bc = sa (s, t, c, m)
        PRINT bs, bc
    END
```

Output:

Enter the initial state (starting point) = 1.0
Enter the initial temparture = 12
Enter the cooling rate (b/w 0 to 1) = 0.2
Enter the number of iterations : 2.5
i.1 : CS = 9.27 , CC = 85.99, Temp = 2.400
i.2 : CS = 9.25 , CC = 88.61, Temp = 0.4800

I5 . 5 = CS = 3.5 , ce = 12.83, Temp 0.000
But state : 3.58 best ensy :- 12.83

26/11/24

LAB 05:

Stimulated Annealing Algorithm

code:-

```
import numpy as np
import math
import random


def objective_function(x):
    """Objective function to minimize: f(x) = x^2"""
    return x ** 2


def simulated_annealing(initial_state, initial_temp, cooling_rate, max_iterations):
    """Simulated Annealing algorithm to find the minimum of the objective function."""

    current_state = initial_state
    current_energy = objective_function(current_state)
    best_state = current_state
    best_energy = current_energy

    temp = initial_temp

    for iteration in range(max_iterations):
        # Generate a new candidate state by perturbing the current state
        candidate_state = current_state + random.uniform(-1, 1)
        candidate_energy = objective_function(candidate_state)
```

```
        # Calculate energy difference

        energy_diff = candidate_energy - current_energy


        # If the candidate state is better, or accepted with a certain probability

        if energy_diff < 0 or random.uniform(0, 1) < math.exp(-energy_diff / temp):

            current_state = candidate_state

            current_energy = candidate_energy


            # Update best state found

            if current_energy < best_energy:

                best_state = current_state

                best_energy = current_energy


        # Cool down the temperature

        temp *= cooling_rate


        # Print the current state and temperature for debugging

        print(f"Iteration {iteration + 1}: Current State = {current_state:.4f}, Current Energy = 
{current_energy:.4f}, Temperature = {temp:.4f}")


    return best_state, best_energy


# Get user input for parameters

try:

    initial_state = float(input("Enter the initial state (starting point): "))
```

```
    initial_temp = float(input("Enter the initial temperature: "))

    cooling_rate = float(input("Enter the cooling rate (between 0 and 1): "))

    max_iterations = int(input("Enter the number of iterations: "))


    # Validate cooling rate

    if cooling_rate <= 0 or cooling_rate >= 1:

        raise ValueError("Cooling rate must be between 0 and 1.")


    # Execute the simulated annealing algorithm

    best_state, best_energy = simulated_annealing(initial_state, initial_temp, cooling_rate,
max_iterations)


    # Output the best state and energy found

    print(f"Best State: {best_state:.4f}, Best Energy: {best_energy:.4f}")


except ValueError as e:

    print(f"Invalid input: {e}")
```
output:-

```
Enter the initial state (starting point): 10
Enter the initial temperature: 12
Enter the cooling rate (between 0 and 1): 0.2
Enter the number of iterations: 25
Iteration 1: Current State = 9.2736, Current Energy = 85.9995, Temperature = 2.4000
Iteration 2: Current State = 9.2528, Current Energy = 85.6140, Temperature = 0.4800
Iteration 3: Current State = 8.4448, Current Energy = 71.3150, Temperature = 0.0960
Iteration 4: Current State = 8.0267, Current Energy = 64.4277, Temperature = 0.0192
Iteration 5: Current State = 8.0267, Current Energy = 64.4277, Temperature = 0.0038
Iteration 6: Current State = 7.1132, Current Energy = 50.5978, Temperature = 0.0008
Iteration 7: Current State = 7.0877, Current Energy = 50.2356, Temperature = 0.0002
Iteration 8: Current State = 7.0877, Current Energy = 50.2356, Temperature = 0.0000
Iteration 9: Current State = 6.8309, Current Energy = 46.6618, Temperature = 0.0000
Iteration 10: Current State = 6.8309, Current Energy = 46.6618, Temperature = 0.0000
Iteration 11: Current State = 6.8309, Current Energy = 46.6618, Temperature = 0.0000
Iteration 12: Current State = 6.1567, Current Energy = 37.9046, Temperature = 0.0000
Iteration 13: Current State = 6.1567, Current Energy = 37.9046, Temperature = 0.0000
Iteration 14: Current State = 6.1567, Current Energy = 37.9046, Temperature = 0.0000
Iteration 15: Current State = 6.1567, Current Energy = 37.9046, Temperature = 0.0000
Iteration 16: Current State = 6.1567, Current Energy = 37.9046, Temperature = 0.0000
Iteration 17: Current State = 6.1567, Current Energy = 37.9046, Temperature = 0.0000
Iteration 18: Current State = 6.1567, Current Energy = 37.9046, Temperature = 0.0000
Iteration 19: Current State = 6.1567, Current Energy = 37.9046, Temperature = 0.0000
Iteration 20: Current State = 5.2467, Current Energy = 27.5274, Temperature = 0.0000
Iteration 21: Current State = 5.2467, Current Energy = 27.5274, Temperature = 0.0000
Iteration 22: Current State = 5.2467, Current Energy = 27.5274, Temperature = 0.0000
Iteration 23: Current State = 4.5909, Current Energy = 21.0761, Temperature = 0.0000
Iteration 24: Current State = 4.3835, Current Energy = 19.2152, Temperature = 0.0000
Iteration 25: Current State = 3.5823, Current Energy = 12.8326, Temperature = 0.0000
Best State: 3.5823, Best Energy: 12.8326
```