Assignments for Geophysical Inverse theory (PHY-NGRI-3-4003), AcSIR-NGRI

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If-else

1. Write a program to find if a number is even or odd.
2. Write a program to calculate the hypotenuse (c) of a right-angle triangle with sides as a,b,c. Make it fail-safe from wrong type entry (e.g. non-negative, complex, infinity, etc.).

For loop

3. Find all the prime numbers from 1 to 100.
4. Find the location and total count of vowels in a given string, e.g., if the sting is– MISSISIPPI, then the program should return location as [2,5,7,10] and total count as 4.
5. Check if a string is palindrome.

Function

6. Write a function to calculate the compound interest.
7. Write a function which takes input and output area/vol for different objects.
8. Write a function to find the number of notes (sample of notes: 10, 20, 50, 100, 200 and 500) against a given amount.

Recursion

9. Find the factorial of a given number which is given by $n! = n(n-1)\ldots 3.2.1$.
10. Write a function to calculate the Fibonacci series upto n-terms. The nth term in Fibonacci series is defined by

$$F_0 = 0$$
$$F_1 = 1$$
$$F_n = F_{n-1} + F_{n-2}$$

11. Write a function to find the perimeter of a circle by approximating it with the n-side polygon and show it is equal to $2\pi r$. The parameter of a n-side polygon is given by $P = 2nR\sin\left(\frac{180}{n}\right)$

Plotting

12. Plot Bessel functions of first and second kind. Compare it with modified Bessel functions of first and second kind.
13. Plot the gravity and magnetic response due to a sphere.
14. write a program to solve two linear equations

$$3x + 4y = 10 \quad (1)$$
$$8x - 2y = 2 \quad (2)$$

    Plot both equations and the solution over the plot.
15. Write a program to check if a coordinate (x, y) is in the i) circle of radius 10; (ii) triangle formed by (0,0), (5,5), (4,0) Plot the region and the point
16. From seismology take earthquake example. Assume its center is at (0,0) and three receivers are laid at $R_1 = (0, 1)$, $R_2 = (5, 0)$, $R_3 = (3, 5)$. If the medium velocity is unity, then first calculate the time taken by wave to reach the receivers.
    Now work in reverse fashion, use the travel-time (just calculated) and receiver location try to locate the earthquake center.

Linear Inverse theory

Problem 1
Assume that you are provided with data, presented in table below

x	1	2	3	4	5	6	7	8	9	10
d	109.4	187.5	267.5	331.9	386.1	428.4	452.2	498.1	512.3	513

Table 1: In table, x represents the location and d represents the data.

and you are asked to find a model for this data in the following form $d = a + bx + \frac{c}{2}x^2$. Here a, b, c are the model parameters and x is the variable defining observation point. For this purpose, write a Python script which performs following.

(a) Estimates a least square solution for the above problem, and make an assessment with suitable tests for the solution.

(b) Estimates a weighted-least-square solution. How it affects your solution?

(c) Estimates a solution using SVD decomposition. Write your observations about the solution.

(d) Plot the observed data and the fitted model for each case.

Problem 2: Tomography problem Assume that the model is divided into several blocks with the respective velocities v_{ij}. Assume the given geometry with a straight ray assumption. Preform following tasks

(a) Assume a low variation in v_{ij}

(b) Calculate the travel time, T

(c) Generate synthetic data= T+5%Noise

(d) Use appropriate method to invert this model.

(e) If you are give freedom to add more data to improve the result which line you will add and why.

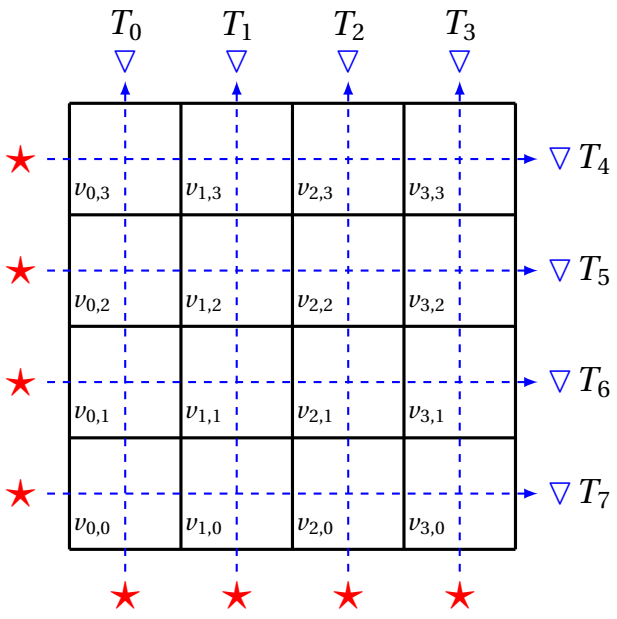

Figure 1: Source and receiver geometry used for tomography problem.

Genetic algorithm

In this exercise you will perform two iterations of GA to find the minima of the following function. You may do it using Python (preferred) or manually.

Function To be minimized	$\boxed{f(x,y) = (a-x)^2 + b(y-x^2)^2}$
Assume the constants	$a = 1, \quad b = 100$
Domain Siz3	$x \in \{-1.5, 2\}$ and $y \in \{-.5, 3\}$
Resolution	$\delta m = \{.001, .001\}$
Population size	5 (for manual) 20(for python)
Number of generations	2

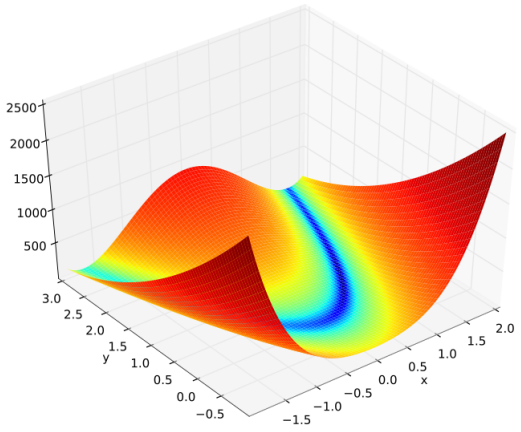

Figure 2: The image for the function to be minimized.

Following are the steps to be performed.

1. Calculate the total length of the chromosome.
2. Initialize the population and calculate its fitness (shown below).

	B_x				B_y					I_x	I_y		x	y		fit
1	0	1	1	0	0	1	1	1		6	7		1.2	1.4		12.4
2	1	0	0	1	0	1	1	0	$\Rightarrow$	9	6	$\Rightarrow$	1.8	1.2	$\Rightarrow$	57.23
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$		$\vdots$	$\vdots$		$\vdots$	$\vdots$		$\vdots$
n	1	1	1	1	0	0	1	0		15	2		3.0	0.4		98.78

   Note: The values indicated maynot be correct, but helps in illustrating the procedure.
3. Select any two individuals (randomly).
4. Perform single point crossover and mutation.
5. Calculate fitness of all new individual.
6. Select individuals for the next generation according to fitness (best fit).
7. Repeat for given number of generations