

Reply to Dr. Stanley Raj, Reviewer

Dear Dr. Stanley Raj, Reviewer

Nonlinear Processes in Geophysics

First of all we would like to wish a happy and prosperous healthy new year to you and your family. We would appreciate your nice and very useful quarries/comment on our submitted manuscript entitled “ Inversion, Assessment of Stability and Uncertainty of Geoelectric Sounding data using a New Hybrid Meta-heuristic algorithm and Posterior Probability Density Function Approach” by Kuldeep Sarkar and Upendra K. Singh.

We try our level best to furnish all those useful comment one-by-one here, which improve our knowledge. Still if you have some other comments for improving our manuscript for publication in reputed journal like Nonlinear Processes in Geophysics (NPG), we are very happy to carry out in future.

With kind regards

Upendra K. Singh

Comment 1: I appreciate the authors effort to attempt a new hybrid metaheuristic algorithm for inverting geoelectrical data

Reply: Dear Reviewer, first of all we would like to thanks for encouraging and appreciating our work to invert the geoelectrical datasets.

Comment 2: Many neural networks algorithm works better than other algorithm. What is the significance of using vPSOGWO optimization algorithm.

Reply: As per my knowledge, there are three main steps in neural networks algorithm: (i) training process, which is time consuming process (ii) validation and (iii) testing. As validation and testing completely depends on how training data is. Second thing is that ANN requires initial guess.

During the training process, ANN uses an optimizer. There are mainly two type of optimizer first is local optimizer. In ANN mostly local optimizer are used (i.e., steepest descent or gradient descent algorithm), therefore most network get stuck at local optima and results become worst, whereas network have least possibility to stuck at local optima in the case of global optimizer (i.e. metaheuristic global optimizer namely PSO, GWO, vPSOGWO etc) and it give global solution.

In contrast to ANN, Global optimization does not required initial guess and there is no such training process. If the initial guess is wrong than it may lead to local minima. For more detail, you may go through given literature: Chen, G. and Yu, J., 2005, August. Particle swarm

optimization neural network and its application in soft-sensing modeling. In *International Conference on Natural Computation* (pp. 610-617). Springer, Berlin, Heidelberg.

Comment 3: What about the computational time and memory for using this algorithm in comparison with other conventional methods?

Reply: We observed using many geophysical examples and found that the computational time for using this algorithm will be higher in comparison with other conventional methods. But this global optimization techniques are computationally inexpensive in terms of both memory requirements and speed. It does not need gradient information, as the gradient-based algorithm does. This allows functions whose gradients are either unavailable or computationally expensive to be solved. You may read the given literature: Chen, G. and Yu, J., 2005, August. Particle swarm optimization neural network and its application in soft-sensing modeling. In *International Conference on Natural Computation* (pp. 610-617). Springer, Berlin, Heidelberg).

Comment 4: Note down the advantages, disadvantages and constraints of the algorithm.

Reply:

Advantages: There are many advantages of Global optimization particularly our algorithm (vPSOGWO): (i) any initial guess does not require, (ii) the error between observed and computed data will be lesser than local optimization, (iii) accuracy in model will be remarkably high, (iv) avail to search whole search space (explore) and converge (exploit) to find global minima (Zhang et al., 2021), and (v) it is computationally inexpensive in terms of both memory requirements and speed.

Disadvantages: This needs high computational cost in terms of time. But faster in finding result with higher accuracy compared to PSO, GWO and conventional algorithms (Cheng et al., 2021).

Constraints: There is no such constraint required in the global optimization techniques.

References: Zhang, X., Lin, Q., Mao, W., Liu, S., Dou, Z. and Liu, G., 2021. Hybrid Particle Swarm and Grey Wolf Optimizer and its application to clustering optimization. *Applied Soft Computing*, 101, p.107061.

Cheng, X., Li, J., Zheng, C., Zhang, J. and Zhao, M., 2021. An Improved PSO-GWO Algorithm With Chaos and Adaptive Inertial Weight for Robot Path Planning. *Frontiers in Neurorobotics*, 15.

Comment 5: How principle of equivalence problem can be avoided by using this algorithm?

Reply: Using any inversion methods, equivalency problem cannot be avoided. Our findings show that the equivalency problem related to the sedimentary layer has been much minimized

Comment 6: Which model of the algorithm works well and give more performance – Forward-Inverse modelling?

Reply: Here there is confusion in Forward and inverse modelling. Using the forward modelling the geophysical data is created from the some specific geological model, whereas geophysical data is inverted by inverse modelling for getting the model i.e. geological model.

In general, the laws of physics provide the means for computing the data values given a model. This is called the "forward problem". In the inverse problem, the aim is to reconstruct the model from a set of geophysical measurements (Snieder, and Trampert, 1999).

Reference: Snieder, R. and Trampert, J., 1999. Inverse problems in geophysics. In *Wavefield inversion* (pp. 119-190). Springer, Vienna.

Comment 7: Random weights have been fixed for working out the algorithm. Have the authors applied any specific logic in fixing the weights or else any meaning approach implemented? Clarify.

Reply: The vPSOGWO algorithm uses a variable weight which lies between 0 to 1 with iteration, allowing a particular weight at each iteration that help in falling into local minima cause by using constant inertia or linearly decreasing inertia weight (Hu et al., 2018). This weight controls the convergence behavior of vPSOGWO, resulting in reliable solution and faster convergence. Thus this weight is completely different from the weight obtained during the training in neural network.

Reference: Hu, Z., Zou, D., Kong, Z. and Shen, X., 2018, June. A particle swarm optimization algorithm with time varying parameters. In *2018 Chinese Control And Decision Conference (CCDC)* (pp. 4555-4561). IEEE.

Comment 8: What are the types of noises involved in training the algorithm? What about SNR?

Reply: We have applied here Metaheuristic algorithm namely vPSOGWO, GWO and PSO to invert the VES data and find the layer parameters. Here, some amount of Gaussian noise is usually added in the synthetic datasets for analysis of the algorithms to make field environment. In this technique training is not required whereas training is one important part of ANN/Machine learning.