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PSO vs. GA vs. VFSA: A comparison of performance, accuracy and resolution with respect to inversion of SP data.

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Introduction

The process of geophysical inversion is pivotal to data interpretation. It aims to find the closest fitting relationship between the observed and computed data obtained henceforth. The target of finding the best model among viable alternates that produces the least deviation from the observed data is known as optimization. This paper aims to compare three global optimization methods namely Genetic Algorithm (GA), Very Fast Simulated Annealing (VFSA) and Particle Swarm Optimization (PSO) in reference to inverting Self Potential (SP) data.

Algorithms

Genetic Algorithm (GA) is a global optimization algorithm that mimics the process of biological evolution to find the best solution. It operates by meta-heuristic way which generates solution to optimization problems using techniques inspired by natural evolution such as inheritance, mutation, selection and crossover. Solutions are represented generally in strings of real numbers. Unlike GA, Particle Swarm Optimization (PSO) is a population based stochastic optimization technique which works on principle inspired by social behavior of bird flocking. Convergence to obtain optimum solution is carried out by calculating fitness value at each iteration and correcting those using local and global best in the neighborhood. On the other hand, Very Fast Simulated Annealing (VFSA), a variant of Simulated Annealing simulates the physical process of annealing which cools a heated object very slowly to minimize the randomness in the system and hence the energy. Here the error function is the analogous equivalent of energy that is optimized to reach a global minima.

Forward Equation

$K[(x-x_0)\cos(a)+(z)\sin(a)]/[(x-x_0)^2+z^2]^q$

Data and Models

Self-Potential (SP) anomalies in general are used for mineral and ground water exploration. The SP anomaly due simple geometric bodies is given by a simple equation which forms the forward problem in this inversion scheme and gives the position(x_0), depth(z), dipole moment(K),shape(q) and angle of polarization(a) of the source body. The algorithms were tested on the basis of their performance, accuracy and flexibility. Mean Square Error was taken as the objective function in all the cases. Both synthetic and field data were used to evaluate the algorithms. Among synthetic data there were both noise free and noise corrupted data sets generated by bodies of spherical and cylindrical shapes. To increase the complexity, a combination of two sources in the same profile was also implemented with after adding 20% random noise. Additionally, a resolution test was performed which outlined the ability of an algorithm to resolve two closely placed bodies exhibiting SP anomalies. The distance between the two sources was initially kept at 10m with 10m increments in the subsequent data sets. Finally, two field datasets from Balangir, India and Vilarelho da Raia region, Portugal were inverted and the results were compared. While the former field dataset was a single source anomaly, the latter was a two source anomaly. The comparative plots of the field anomalies are shown in Fig. 1b and Fig. 1c while those of a two source anomaly and one of the resolution tests are shown in Fig. 1a and Fig. 1d respectively.

Conclusions

All the three algorithm were coded in FORTRAN77. The results obtained by three algorithms were comparable. However, the resolution capability of VFSA was the best followed by PSO and VFSA. PSO obtained the optimum results quicker than the other two. The variable probabilistic parameters were the least and very well established in the case of PSO. As a result fine gained control over the algorithm was quite easy. However, with GA and VFSA there were more probabilistic parameters which made fine tuning quite an effort.

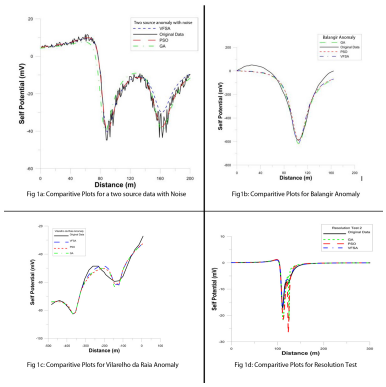

Fig 1a: Comparitive Plots for a two source data with Noise

Fig 1b: Comparitive Plots for Balangir Anomaly

Fig 1c: Comparitive Plots for Vilarelho da Raia Anomaly

Fig 1d: Comparitive Plots for Resolution Test

キーワード: Self Potential, Inversion, Optimization, Particle Swarm Optimization, Very Fast Simulated Annealing, Genetic Algorithm
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