Target-oriented optimized survey design and quantitative comparison for 3D electrical resistivity tomography

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In recent decades, geoelectrical methods have played a very important role in near-surface investigation. The most widely used of these methods is electrical resistivity tomography (ERT). Regardless of the forward and inversion algorithms used, the original data collected from a survey is the most important factor for quality of the resulted model. However, 3D electrical resistivity survey design continues to be based on data sets recorded using one or more of the standard electrode arrays. There is a recognized need for the 3D survey design to get better resolution using fewer data. Choosing suitable data from the comprehensive data set is a great approach. By reasonable selecting, better resolution can be obtained with fewer electrodes and measurements than conventional arrays. Previous research has demonstrated that the optimized survey design using the ‘Compare R’ method can give a nice performance.

This paper adds target-oriented selection and modified the original ‘Compare R’ method. The survey design should be focused on specific target areas, which need a priori information about the subsurface properties. We select electrodes and configurations as the target set by the comprehensive set firstly which meets the requirements of the target area. The number of measurements and electrodes is much less than the comprehensive set and the model resolution matrix takes less time to calculate. At the next step for rank, we calculate the sensitivity matrix of the target set only once and then calculate the contribution degree of each measurement separately from it. The time of iterative calculation of the resolution matrix when measurements set changing is less than the original method.

The traditional method of evaluating RMS is not appropriate for comparing the quality of collected data by different survey designs. SSIM (structural similarity index) gives more reliable measures of image similarity better than the RMS. The curves of SSIM values in three dimensions and the average SSIM are given as quantitative comparisons. Besides, the frequency of electrodes utilized given to guides on selecting the highest used electrodes. Finally, the curves of the average relative resolution S and the number of electrodes as the number of measurements increase are given, which proves the method works effectively.

The results show the significance of using target-oriented optimized survey design, as it selects fewer electrodes and arrays than the original CR method. Also, it produces better resolution than conventional arrays and takes less calculation time. 3D SSIM, frequency of electrodes used, the
relationship between average relative resolution, number of electrodes and number of measurements, these quantitative comparison methods can effectively evaluate the data collected in various survey designs.