JOINT-INVERSION METHODOLOGICAL DEVELOPMENT OF 2-D RESISTIVITY MODELING METHOD FOR NEAR SURFACE STUDY

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ABSTRACT

This paper presents the joint-inversion methodological development of 2-D resistivity modelling method. This approach is reached with the developed joint inversion of two different data sets using data levels amalgamation (DLA) technique. The study showed that joint inversion is suitable approach to image the subsurface structures and targets. The main objective in this study is achieved with the synthetic model and field test. The synthetic model is used as survey plan to investigate the respond of selected array towards targets. The field test is used to verify the technical merit of the developed technique in this study. It shows that, this technique is useful for high resolution 2-D resistivity modelling. In addition, the interpretation of infiel study is supported by inline-borehole. The study is extended with the comparison of two different arrays, namely Wenner-Schlumberger and newly developed array called Andy-Bery arrays. The results show that this array is capable to image the three targets with acceptable location and right resistivity value compared to Wenner-Schlumberger array. Thus, it shows that joint-inversion 2-D resistivity modelling is a good way to solve limitation that might be rise for one single array.

Key words: Joint-inversion; Resistivity; Amalgamation; Synthetic.

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1. INTRODUCTION

Electrical resistivity tomography (ERT) method is one of the geophysical method [1]. This non-destructive is works by measuring the potential at a pair of potential electrode while injecting current at a pair of current electrode. This geophysical method also known as electrical method for environmental studies [2,3,4] and engineering studies [5,6,7]. Many researchers used this together with other geophysical methods such as seismic refraction [8,9], ground penetrating radar [10,11] and magnetic [12]. Recently, many efforts have been made to increase the technical merit of this geophysical method. One of the approach is to use joint-inversion method in geophysical data [13,14,15]. Joint inversion method is develop for
resistivity and seismic refraction data [13]. They have used sharp-boundary models with typically three layers. In addition, the study also demonstrated the approach usefulness using case studies related to geotechnical investigation and shallow groundwater exploration. Joint inversion of Schlumberger resistivity and time-domain electromagnetic data was carried to resolve power of different scheme of inversions [14]. This similar approach has been used for mapping coastal aquifers [15]. The joint inversion of direct current and time domain electromagnetic soundings methods. The study was carried out at three test sites. Besides that, that joint-inversion also used with different data sets of 2-D resistivity [16] and 2-D induced polarization [17] and time-lapse of resistivity [18] data sets. Based on these previous studies, we can conclude that single inversion of resistivity data set is a non-unique solution. In addition, the used of joint inversion method is capable to produces more tightly constrained of model interpretation compared to single data set independently [15,16,17,18].

In this study, joint inversion methodological development of 2-D resistivity modelling method is developed using three different arrays. Then, joint inversion of these three different arrays from three data sets is inversed as one data sets. This approach is carried out using data level amalgamation (DLA) technique [1,2]. In addition, to study the effectiveness of this joint inversion method, this study presents an array called Andy-Bery array [19]. In application, the effectiveness of this array toward known target is investigated too.

2. METHODOLOGY
In this study, 2-D computerized modeling method is used to create a model with certain targets. In the model, there is a single model of block with resistivity value of 10 ohm.m. Then this single block is surrounded by a layer with resistivity value of 1000 ohm.m. Then, the second layer at the lower part is set to be with resistivity value of 2000 ohm.m (Figure 1). For this synthetic modeling method, the data set is added with apparent resistivity noise of 3 %. This consideration is made to set the synthetic model is closed to the actual environmental where there is some noise in the data set [19]. After created the model (Figure 1), the array type is selected from the option. Three different arrays are selected for to be used in this study. They are Dipole-Dipole (D-D), Pole-Dipole (P-D) and Wenner-Schlumberger (W-S) arrays. Then, the model data is saved in RES2DINV format for inversion process. Figure 2 shows the apparent resistivity arrangement for all three different arrays. They are marked with different colour and shapes as shown in the legends. From the Figure 2, it shows that there are mixing of apparent resistivity data to create a single model from three different arrays. This approach is called data levels amalgamation (DLA) technique [19]. In the inversion process, this data set is used as joint inversion to produce a single model instant of each three different arrays. This approach is give a constraint inversion and therefore will increase the technical merit of this method.

The study also set one field test to investigate the usefulness of this technique in the Earth subsurface imaging. The field test is carried out at Perak, Malaysia. Three different array is used namely D-D, P-D and W-S. The minimum electrode spacing is 5 m and the length of survey line is 200 m. The field test area is comprised of alluvium, granitic rock and tefra dust [20,21,22]. The area is dominated with granitic rock which is originated from Bintang Range [20,21,22]. The alluvium unit is contained of alluvium and tefra dusts.
3. RESULTS AND DISCUSSIONS

The results showed that the technique developed in this study is capable to resolve the target in the computerized modelling. The target of a block is resolved with good. It shows that the location and resistivity value are correct. The single block is resolved with 10 ohm.m and the location is acceptable. The black solid line in Figure 3 shows the actual location of the block. The upper layer with thickness of 6.44 m is resolved with good. This layer is imaged with the resistivity value of 1000 ohm.m (Figure 3). However, the lower layer (below than 6.44 m) is not well resolved. The resistivity of the lower layer especially below the block is not well resolved with correct resistivity value. Only lower left and lower right side of the block is resolve with good. The resistivity value is acceptable with 2000 ohm.m (Figure 3).
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Figure 3 The synthetic model results from the computerized modelling.

The result for the field test is shown in Figure 4. The field test results showed that the study area is identifies with two main layers. The upper layer is interpreted as overburden which is formed from the weathering process. This overburden is identified as alluvium [20,21]. This alluvium is interpreted with resistivity values of 89.2 – 1173 ohm.m. The second layer is interpreted as weathered granitic bedrock with resistivity values greater than 1173 ohm.m.

Figure 3 Joint inversion of three different arrays (D-D, P-D and W-S) for field test.

The second approach in this study is to introduce a novel array in resistivity method. This hybrid array is called Andy-Bery array [19]. This array is developed from the combination of two array. They are Wenner-Beta array and Dipole-Dipole array [19]. This approach is started with initial synthetic model, then followed by comparison with W-S array. Figure 4 shows the initial model with 3 blocks as the targets with resistivity value of 10 ohm.m. These targets is surrounded by a layer with resistivity 1000 ohm.m.
Figure 4 The initial synthetic models with three different targets location surrounded a layer.

Figure 5 shows the inversion results of Wenner-Schlumberger (W-S) and Andy-Bery array. The actual location of the three blocks is illustrated with black solid lines. The results showed that W-S array able to image the upper two block location, but this array gives wrong resistivity value (Figure 5A). W-S array gives resistivity values of 70 – 150 ohm.m. The lower (bottom) block is not resolve with good. W-S array cannot image the right location and resistivity value of the three targets.

Figure 5B shows the results of inversion using Andy-Bery array. This array is capable to resolve the three blocks of targets with good. This arrays able to image the location and resistivity value with right. The actual location of the targets is illustrated with black solid lines. The Andy-Bery array also able to image the targets with acceptable resistivity value which is similar to the initial synthetic model. Based on this comparison it shows that Andy-Bery array is more suitable to image blocky target compared to W-S array. This is shown by investigated parameters such as actual location and actual resistivity value of the three targets which have been set in initial synthetic model.

4. CONCLUSIONS

In conclusion, this study showed that joint inversion is a suitable approach to image the subsurface structures and targets. The joint inversion in this study is developed using a technique called data levels amalgamation (DLA). The main objective in this study is achieved with the synthetic model and infiel study. The field test is used to verify the technical merit of the developed technique in this study. This geophysical method is suitable to image the near subsurface structures which is related to environmental studies [16,22,23]. The study is extended with the comparison of two different arrays, namely Wenner-Schlumberger and Andy-Bery arrays. It shows that Andy-Bery array is suitable to image the targets (three blocks) with acceptable location and resistivity value.
Figure 5 Inversion results for (A) Wenner-Schlumberger array and (B) Andy-Bery array. The solid black lines is the actual location of the three blocks with resistivity value of 10 ohm.m.

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