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Shear wave velocity modeling by inversion of HVSR data using CJAYA algorithm

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Keywords

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Inversion
Single station

Extended Abstract

Summary

Determination of the shear wave velocity (Vs) profile and natural frequency (F_0) is significant in site effects studies. There are different techniques for estimating the Vs and F_0, e.g., downhole measurements and gathering geophysical data on the surface. In this regard, geophysical methods, due to their fast procedures of recording and processing of data, are very popular. One of the most popular geophysical methods for site effects studies is microtremor method. In recent years, microtremor data are used frequently in site effects studies. Array microtremor and Rayleigh waves ellipticity methods are two techniques that are based of processing of recorded microtremor waves or ambient noise. In contrast of array microtremor method, Rayleigh waves ellipticity method needs just to a 3C seismometer for recording the ambient noise. This method is also named single station microtremor method or Nakamora method that is based on the calculation of the ratio between the horizontal and vertical spectra of the seismic ambient noise. After calculating horizontal-to-vertical spectral ratio (HVSR), it should be inverted to estimate the Vs profile. In current study, a new inversion algorithm, i.e., CJaya algorithm is introduced for inverting of HVSR data. The proposed method is tested on synthetic and real datasets. The findings show the capability of the proposed method in the inversion of HVSR data.

Introduction

Site effects investigations for seismic prone areas are vital. One of the key ways to study site effects is the modeling of Vs. In the last decade, ambient noise is widely used in Vs modeling. HVSR method is very fast and cost-effective method for Vs modeling. By inversion of HVSR curve, the Vs profile can be calculated. For inversion of HVSR curve, access to priori information such as geological information, downhole data or other geophysical data is significant. The priori information helps to reduce ambiguities in the results. However, applying an appropriate inversion algorithm for calculating Vs profile is very important. In the current study, a new inversion framework, based on a metaheuristic algorithm, i.e. Jaya algorithm, is developed. It is a customized Jaya algorithm, CJaya, that is used to invert the HVSR data.

Methodology and Approaches

In order to develop CJaya algorithm, a new mutation operator is added to the standard Jaya algorithm. The proposed mutation strategy combines the search information of the global best particle/answer and two other random particles. In the applied CJaya inversion method, a dynamic mutation rate, based on the number of model layers and population, was used. The CJaya approach can accelerate the convergence speed in comparison to the standard Jaya. CJaya inversion algorithm is tested on synthetic and real datasets. The applied algorithm is written in MATLAB environment. In the procedure of the inversion, the forward code based on the viscoelastic Kelvin-Voigt model has been used to compute the site response of horizontally stratified soil layers. To assess the applicability of the proposed algorithm in case of synthetic data, 15% noise has been added to the data, and then, the data has been inverted using the CJaya algorithm. The inversion results of the synthetic data with and without noise were acceptable. Furthermore, the inversion process using the CJaya algorithm, in comparison to standard Jaya algorithm, was fast and showed smaller estimation error.

The results of real dataset inversion were in good agreement with pervious information from the study area.

Results and Conclusions

In general, in comparison with the Jaya algorithm, the proposed CJaya inversion algorithm was more accurate, simpler, faster, and easier to implement on a HVSR dataset. Appropriate accuracy of the proposed method was confirmed from applying it on both synthetic and real datasets. It can be concluded that the CJaya inversion method can be used for inversion of other geophysical datasets.