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CLUSTERING OF EARTHQUAKE RECORDS BY A HYBRID OPPOSITION-SWITCHING SEARCH

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INTRODUCTION

Various methods have been proposed for clustering, including k-means algorithm (Shahrouzi & RashidiMoghadam, 2016). It is known as a commonly used and widely used technique. But because of the dependence of the result of this algorithm on the initial point, in the present study, its combination with the algorithm Opposition-Switching Search is presented. In this paper, the data matrix provides over 100 records of earthquakes on different types of soils, fault mechanisms and magnitudes. To form the matrix, various attributes such as seismic energy, peak movement rates, velocity and acceleration of strong ground motion, spectral intensity and also earthquake duration have been used. Then, clustering is performed using a new hybrid method and is compared with the traditional k-means. The results of several tests indicate an improvement in the evaluation indicators such as the profile index. In the present study, Silhouette Value Indicators have been selected in the objective function.

OPPOSITION SWITCHING SEARCH

Opposition-Based Learning, OBL is a recent issue for performance improvement of certain procedures in artificial intelligence. Shahrouzi (2019) first used OBL to develop a population-based algorithm called Opposition-Switching-Search, OSS. It is suitable for continuous optimization and utilizes the following features:

- Information sharing between the search-agents. It is performed via a crossover to generate a pseudo-mean solution by picking up any of its components from randomly chosen members of the population.
- Taking into account opposition of a solution as well. A simple definition is utilized so that opposite of a typical solution X is given by:

$$\tilde{X} = X^U + X^L - X \tag{1}$$

where X^L and X^U are the corresponding lower and upper bounds, respectively.

- Another feature is switching between a position and its opposition as the starting point for defining movement direction in the search space
- An elitist strategy is also implemented saving the best-found solution as the target of such walks

OSS algorithm is proposed via the following steps:

- Generate a population of n individual agents by randomly locating them in the design space
- Evaluate the objective function for the entire population
- Repeat the following steps until termination criterion is satisfied
  - × Update the best-so-far solution; known as the Global best, X^{Gb}
  - × For every ith individual do
- Generate the sharing solution; Y by

$$Y = C_{i}^{r} s(X^{i}) \quad (2)$$

where $Y = Cr_i s(X^i)$ is a crossover operator on the individuals denoted by X^i.

- Switch the pseudo-mean Z to either Yor $\tilde{Y}$ by equal chance. Take the type-I velocity vector as:

$$V^{I} = rand*(X^{Gb} - Z) \quad (3)$$

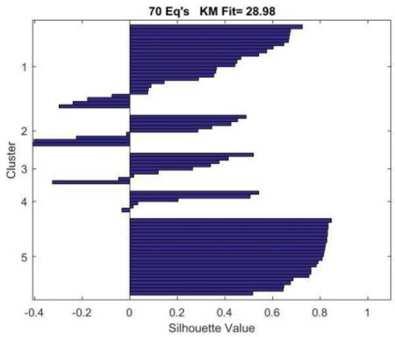
- Switch the type-II velocity V^{II} to either S^1 or S^2 by equal chance. They are given as follows:

$$S^{1} = rand*(X^{Gb} - X^{i}) \quad (4)$$

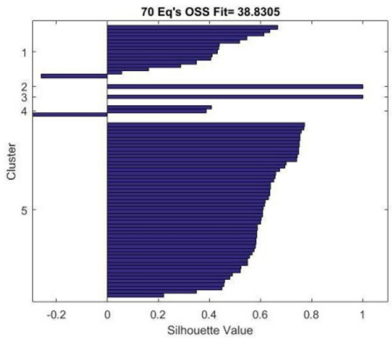
$$S^{2} = rand*(\tilde{X}^{i} - X^{Gb}) \quad (5)$$

- Generate the candidate solution by $X^{Cd,i} = X^{i} + V^{I} + V^{II}$. Modify $X^{Cd,i}$ to fall between its lower and upper bounds.
- Evaluate objective function for the candidate solution
- Substitute X^{i} with $X^{Cd,i}$ if the candidate solution is better than X^{i}.

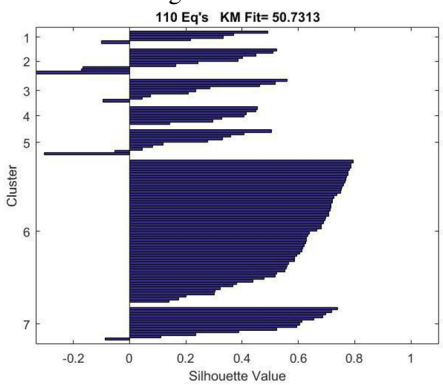
As a common termination criterion for OSS algorithm, it loops up to N Iterations. In this study, 70 earthquake records are subdivided into 5 clusters once using the algorithm k-means and again using the hybrid OSS with k-means. The graphs in Figures 1 and 2 and the resulting index numbers show superiority of the combined algorithm over the k-average method.



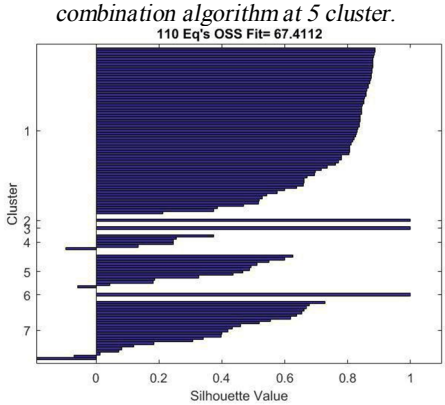
1-The result of clustering 50 earthquake records with the k-means algorithm at 5 cluster.



2-The result of clustering 50 earthquake records with the combination algorithm at 5 cluster.



3-The result of clustering 110 earthquake records with the k-means algorithm at 7 cluster.



4-The result of clustering 110 earthquake records with the combination algorithm at 7 cluster.

In the other word, using the combined algorithm avoids the weaknesses in the k-means algorithm and allows to overpass local optima. In order to improve the clustering quality, application of the proposed meta-heuristic algorithm is recommended.

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