

Title: Machine Learning applied to potential fields

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Research program

The research focuses on the theme of Machine Learning (ML) applied to potential fields (gravimetric and magnetometric anomalies). The project is financed by ENI under the framework agreement between eni and the University of Naples Federico II. The duration is three years. Advanced tools are available for the analysis of gravimetric and magnetometric data aimed at identifying structural lineaments that correspond to variations in density or magnetic susceptibility. Despite of this the introduction of Machine Learning techniques (ML) could, even with a view to big data analysis, help speed up the analysis of large datasets and make fault positioning more reliable, in eni and in industries as well. This especially for determining the crystalline basement, where the seismic reflection often has a poor resolving power. This activity is of importance to help building a more robust geological basin model. For hydrocarbon exploration, large amounts of data are acquired and used in workflows based on physical modeling to identify the geological features of interest such as fault networks, salt bodies or, in general, elements of oil systems. The added modeling phase, which transforms the data into the space of the model and the subsequent interpretation are generally very expensive, both in terms of computing resources and time by the domain expert. The research based on Machine Learning aims to implement a unique approach that bypasses these challenging passages, directly assisting interpretation. This happens through a training on a deep neural network that allows to define a mapping relationship between the data space and the final output. The key to obtaining accurate forecasts is the use of the Wasserstein loss function, which correctly manages the structured output by exploiting the continuity of the error surface. The methodology will represent a new way of using geophysical data to more directly identify the key structural elements in the subsoil.

Proposal for a PhD position

The student must first perform a training phase on the Machine Learning algorithm. Realistic 3D density and magnetic susceptibility models will be generated synthetically, labeling faults for an unbiased Earth model.

Based on these models, magnetic and gravimetric anomalies of faults will be generated. This step will be conducted on thousands of random density / susceptibility model realizations. The parameters include the number of levels in a model, the number of faults, the contrast of density and magnetic susceptibility and the angles of dip and strike for each possible fault. Once the network has been trained, it can be reused many times with minimal cost and can be used with a lot of new data. This will be much less expensive than the elaboration and interpretation of a gravimetric and magnetometric acquisition. Network output is a 3D subsampled voxel grid, with the value of each voxel indicating the probability that the fault is present within the voxel.