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Supervised machine learning to estimate the basement depth by gravity data

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Applications of Machine Learning to the geosciences are increasing in numbers during the last two decades because of its computation power. In this work we propose a method to estimate the basement depth from gravity data using a supervised machine learning approach. We used the Bishop synthetic model to represent a variety of examples of input – target (i.e., gravity data – depth of the basement) training dataset. We so generated a large set of examples, using an overlapping moving window along the profiles in the N-S and E-W direction, associating the corresponding depth values of the basement to each of the windows. Due to its data-driven nature, the neural networks perform better as the number of examples provided in the training phase increases. However, increasing the number of examples leads to a higher computational cost in terms of speed and hardware needed. In the Big Data era this is not a huge issue, thanks to the increasingly present services of cloud computing. We found a good compromise on an average machine between speed and performance by using about 300k examples. A trial-and-error approach was used to find the hyperparameters that have the best compromise between performance and computation time.

We used, as a testing dataset, the gravity data due to a surface modelled from the Himalaya region DEM, with noisy and noise-free data. We found that this avoided overfitting and helped to verify the ability of the trained network to generalize to other cases, even with noisy data. The method was successfully applied also to a real dataset case: the isostatic anomaly of the Yucca Flat sedimentary basin (Nevada, USA) showing good agreement with previous inverse-modelling of the data, even if the author consider a set of layers with increasing density vs. depth, while in our case we used a mean density contrast of -0.7 g/cm^3.

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