Neural Networks for the Electromagnetic Near Field Subsurface Sensing

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This paper is intended to give an assessment of the application of a neural network approach to the electromagnetic sensing of subsurface scenarios. The neural network approach is used to obtain a reconstruction of the geometric and dielectric properties of buried geometries. Besides, the focus is on the exploitation of aspect-limited electromagnetic data coming from near field measurements, such as those available at the terminals of a ground penetrating radar equipment. This topic is related to many practical applications in environmental and civil engineering, such as, for example, the subsurface mapping of utilities or contaminants, or the monitoring of the subsoil conditions, for buildings, roads or railroads maintenance purposes.

The problem of reconstructing the geometric and dielectric characteristics of buried scenarios is usually formulated as an inverse scattering one. Since, usually, only few parameters can be investigated in order to characterize the unknown target, learning-by-examples techniques have recently been applied to face inverse scattering problems. As a matter of fact, a neural network can be trained to approximate the functional relation between the electromagnetic available measurement data and the unknown characteristics of the scatterer, through the exploitation of a set of examples representative of the problem at hand. Thus, the a-priori information must be effectively exploited to construct a representation of the investigated problem.

The proposed approach is seen to provide a geometrical and physical characterization of buried objects by considering both frequency-domain aspect-limited data (amplitude and phase of the measured scattered field) and time-domain aspect-limited data [1–3]. Different measurement configurations have been tested (both bistatic and multi-offset setups). Besides, we have also considered the problem of reconstructing the properties of layers embedded in a host medium in order to test the potentialities of the neural network approach to reconstruct the subsoil composition. Again, different measurement configurations have been taken into account.

Numerical results will be presented assessing the capabilities of a neural network approach to exploit electromagnetic data to face the reconstruction of subsurface scenarios. Moreover, we also monitored the computational burden of the approach in order to give some indications on the computational resources requirements. The collected data will serve the purpose of underlining, on the one hand, the advantages and, on the other hand, the limitations of the proposed approach.

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