On a machine learning enhanced solution of the inverse source problem

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The inverse source problem in electromagnetics, present in a wide range of applications such as antenna characterization and antenna diagnostics, can be faced by means of the boundary element method and leveraging the surface equivalence principle. In this context, the system to be solved is plagued by two sources of ill-posedness. The first is the null-space due to the existence of non-radiating currents, which are described by the solutions of the homogeneous integral equation associated to the system. The second is related to the evanescent modes, which exponentially decay as the distance between the object under test and the probes increases. Therefore, the physical information quickly falls below the noise level, especially in settings in which the field sampling is performed in the far-field region.

While for the latter source of ill-posedness, the lost information cannot be recovered without the addition of further constraints, the non-uniqueness of the solution due to the former has been handled in numerous ways in the literature. Among them, several schemes select a solution having a given minimum norm (for instance, the well-known Moore-Penrose pseudoinverse) or by requiring additional constraints, such as the enforcement of the Love condition. Although these strategies allow us to select a unique solution, no method can ensure that the reconstructed currents correspond to those that generated the observed field.

Such an achievement would prove to be a perfect solution of the inverse source problem, but it is intrinsically negated by the ill-posedness of the setting. However, it could possibly be approached by enforcing some constraints related to the physical problem which are not directly taken into account by the equations used. As an example, better a priori knowledge of the excitation of an antenna under test or of the field that impinges on a studied scattering object could provide further information, exploitable in order to achieve better reconstruction quality.

In this work, we explore the usage of machine learning techniques that take advantage of some of these a priori hints to attain a closer-to-reality solution of the inverse source problem by means of a transformation of the space of solutions of the system.

During the presentation, theoretical insights will be discussed and complemented by numerical results.

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