URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Gradient based Inverse Scattering Algorithm using Energy Functional with reduced observation points

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The purpose of this manuscript is to investigate an inverse scattering method using only the total electric field data of the observation plane without knowledge of the incident electric field. In this inverse scattering method, the initial boundary value problem is solved from the total electric field data measured at the observation plane[1][2]. Then, we solve the inverse scattering problem from the stored energy of the misfit field between the original problem and the boundary value problem with estimated target in the interior region Ω_i bounded by the observation plane[3]. To solve the problem, it is necessary to continuously measure the total electric field on the observation plane. However, it is desired to reduce the number of observation points. We consider to measure the electric field sparsely on the observation plane and derive the electric field interpolated between the observation points using them. Therefore, we can easily solve the inverse scattering problem. In this study, we show that the proposed gradient inverse scattering method to use cost functional based on the stored energy can obtain the relative permittivity distribution of a two-dimensional target. The cost functional $Q(\mathbf{p})$ is defined as follows

$$Q(\mathbf{p}) \equiv \frac{1}{2}\varepsilon_0 \int_{\Omega_i} \left[\varepsilon_r(\mathbf{r}) \left| \mathbf{E}^{eq}(\mathbf{p}:\mathbf{r},T) \right|^2 + \mu_r(\mathbf{r}) \left| \eta \mathbf{H}^{eq}(\mathbf{p}:\mathbf{r},T) \right|^2 \right] d\mathbf{r} \tag{1}$$

where η is the intrinsic impedance of free space, and $\mathbf{E}^{eq}(\mathbf{p};\mathbf{r},T)$ and $\mathbf{H}^{eq}(\mathbf{p};\mathbf{r},T)$ are the electric and magnetic fields at the time $t=T$ of the boundary value problem with the electrical property distribution $\mathbf{p}$. Moreover, we consider noise to be added to the measured electric field. Several numerical simulations show the validity of the proposed method.

References

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