Latest Advances in Learning-assisted Information Retrieval from Microwave Observations in Biomedical Inverse Scattering and Environmental Sensing

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Abstract— The use of microwave observations has been long established in the fields of biomedical and environmental sensing. While they have quite different observational scenarios and instrumentations, both application areas rely on the interactions of electromagnetics waves in the microwave regime for extracting information from their intended targets. In the environmental sensing applications, the use of airborne and spaceborne radars constitutes a major part of the global Earth observing systems. In biomedicine, microwave imaging systems have been developed for non-ionizing imaging for diagnostic applications, as well as for 3D monitoring during intraoperative procedures. While in the environmental applications the variables of interest are bulk geophysical properties of the Earth landscape (such as soil water content, vegetation density and biomass, and snow water equivalent), in the biomedical domain the variables of interest are high-resolution dielectric and structural properties of biological tissue. Both classes of problems can be formulated via electromagnetic scattering and inverse scattering problems. The solutions to these problems are quite challenging, each in a different way. In both cases, the inverse scattering problem is highly nonlinear and highly under-determined. Over the past decades, many excellent methods have been proposed, yet their solutions are still not complete. It still remains a challenge to obtain good performance metrics such as high resolution, specificity, reasonable computation times, and/or low uncertainty. The introduction of learning-based methods has been quite a breakthrough in addressing many of the shortcomings of traditional inverse scattering methods. In this talk, we will present the latest advances in our group related to both types of problems. For example, we will present various approaches we have developed in the medical imaging domain, such as using a learning-assisted objective function approach [1, 2] and using a physic-assisted learning approach [3], where a neural network is used to refine the image reconstructed from traditional inversions methods such as the Born iterative method. In the environmental sensing domain, we will present our recent work on learning-assisted retrievals of geophysical quantities such as soil water content and surface roughness. The idea is to combine electromagnetics-based scattering and emission models and data from different satellite, airborne, and in-situ sources in a generative adversarial network framework to account for modeling variances and measurement uncertainties, which is expected to allow much more accurate retrievals of said geophysical variables.

REFERENCES

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