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Active Control of Electromagnetic Waves: Optimization Strategies and Applications

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Active manipulation of electromagnetic (EM) fields is reshaping modern communication and sensing technologies. This talk presents our recent research works on optimization-based strategies for controlling EM waves in free space and layered media ([2, 3, 1]), drawing on recent advances in inverse source formulations and numerical schemes. By employing classical regularization methods, such as truncated singular value decomposition and Tikhonov regularization, we demonstrate how stable solutions can be achieved even in ill-posed settings. In particular, we shall look at the effects of these regularization techniques in solving the resulting control equations obtained using either the Debeye potential formulation or the integral equation paradigm.

Applications include adaptive beam shaping, near-field focusing for wireless power transfer, and active cloaking. Sensitivity analyses highlight the limits and feasibility of these approaches, offering insights into how optimization can balance accuracy, energy efficiency, and robustness. The presentation bridges rigorous mathematical foundations with practical engineering outcomes, showcasing active EM control as a powerful paradigm for next-generation communication systems.

Keywords: active EM control, EM field synthesis, regularization techniques, TSVD, Tikhonov regularization

MSC2020: 78A46, 78M05, 78M50

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