Wave control and imaging with reconfigurable intelligent surfaces: from electromagnetism to acoustics

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Abstract

Reconfigurable Intelligent Surfaces (RIS) permit to improve wireless communication between multiple users in challenging environments where multipath and multiple scattering dominated. RISs play the role of a tunable boundary and are mainly studied for electromagnetic and sound waves in a relatively narrowband scenario. They use metasurfaces made of several hundred elements with a tunable impedance that control locally the phase of the reflection coefficient. The way to optimize the phase pattern of the RIS elements is a challenging problem because multipath propagation creates coupling effect between RIS elements and introduces a kind of nonlinear coupling in the way the communication channels depend on the boundary conditions. This coupling between RIS elements can be defined through a reflection matrix or through an impedance matrix that depends of the obstacles located in front of the RIS.
We will discuss different scenarios using RIS, from improving multi-user communications to imaging and sensing. The first one is in the field of multi-user sound communications, designed for multiple carrier frequencies like music, with a room boundary made of several hundred electronically-controlled adjustable Helmholtz and we will show how to optimize experimentally communications between 2 x 2 speakers with a climbing algorithm.

The second approach is designed for transmitting broadband continuous spectra and it used feedback metasurfaces where each elementary cell works as a reconfigurable spatio-temporal filter mimicking a double time-reversal process.
The third approach is in the field of imaging and sensing. It uses a single antenna and a RIS to retrieve remotely the RIS reflection matrix and obtains an image of the RIS environment.

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