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Enhancing Wireless Indoor Communication with Spatial-Microwave-Modulators

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1. Extended Abstract

Since the first demonstration with Spatial-Light-Modulators of the focusing of light after its propagation through a highly scattering medium [1], wave front shaping as technique to control wave propagation through complex media has attracted a lot of interest in Optics. Here we transpose this idea to the microwave domain where indoor environments act like disordered, reverberant cavities for telecommunication signals such as WiFi. By using arrays of simple electronically reconfigurable elements, a so-called Spatial-Microwave-Modulator (SMM), we modify the reflections off the walls, thereby shaping the microwave front. This enables us to focus for instance a WiFi field on a mobile phone, enhancing substantially the received signal intensity.

Firstly, we demonstrate in a proof-of-concept experiment [2] that this technique can enhance the signal strength received at a given position in an office room, by 8.5 dB on average. To identify the optimal SMM configuration, we iteratively identify the best state for one SMM element after the other, similarly to the optimization algorithm used in [1]. We illustrate the focusing effect both in the frequency and spatial domain (cf. Figure 1).

Secondly, we present a theoretical model [3] that predicts the expected intensity enhancement as a function of the office room's volume V and quality factor Q. The model considers the N modes contributing to the spectrum at the working frequency as random walks in the complex Fresnel plane, out of which $p < N$ are controllable after the optimization. The controllable modes are aligned to maximize the resultant amplitude (i.e. the sum of all contributions).

Finally, we present some examples of real-life applications in which we use Spatial-Microwave-Modulators to optimize for instance the WiFi communication of a laptop in real-time.

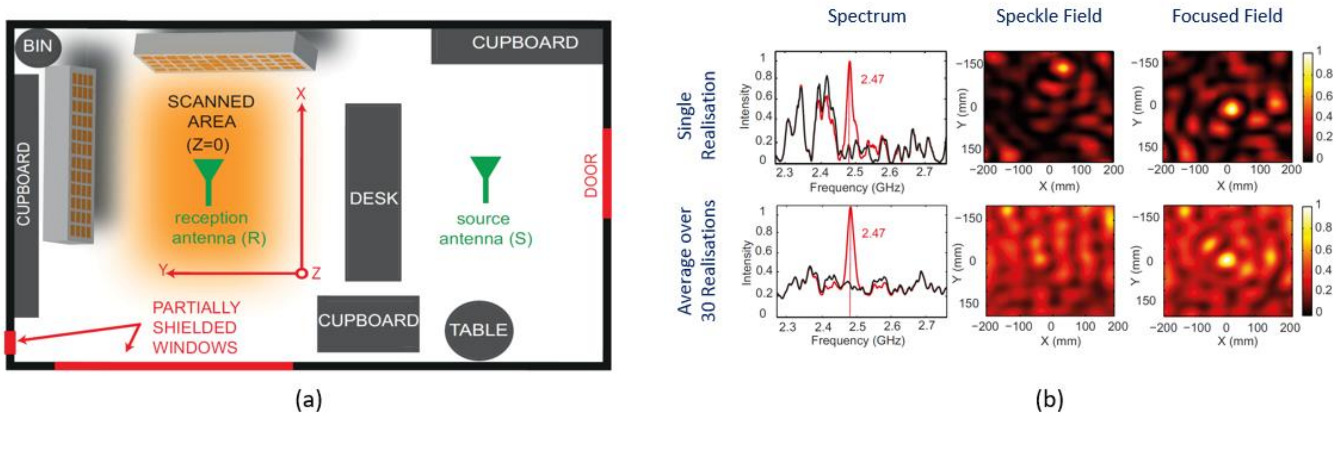

Figure 1. (a) Schematic of the experiment set-up for the proof-of-concept in an office room. (b) Visualisation of the focusing effect in the frequency and spatial domain, for a single realisation on top and averaged over 30 realisations of disorder on the bottom.

2. References

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