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Technical report of RIS-aided communication

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1 Introduction

This brief technical report details the implementation of Reconfigurable Intelligent Surface (RIS)-assisted communication in an indoor single-input single-output (SISO) scenario using MATLAB, available at [1]. To evaluate communication performance, the achievable bit rate (ABR) and signal-to-noise ratio (SNR) are computed. A comparison is made between non-RIS-aided communication (*wRIS*) and RIS-aided communication to highlight the positive impact of RIS in new wireless communications.

2 Development

The communication environment under examination is an indoor scenario in which a wall is positioned to obstruct direct communication between the transmitter (Tx) and receiver (Rx). This is illustrated in Figure 1. In this manner, communication between the two entities is feasible, contingent on reflection off the opposing wall or the deployment of an RIS. The RIS is situated in the yz -plane and comprises N_{ele} elements, distributed at distances of d_y and d_z in the y and z directions, respectively, with a work frequency of 3.5 GHz.

The channel model implemented is in accordance with the specifications set in [2], with a few simplifications. The total channel, H , is divided into three distinct segments:

$$H = g^T \cdot \Phi \cdot h \quad (1)$$

The channel h is between the Tx and RIS, g is between the RIS and Rx, and Φ is the response of the RIS. In this analysis, an unobstructed channel between Tx-RIS and RIS-Rx is assumed, and only the attenuation due to distance is considered.

Each sub-channel is represented with a module (channel attenuation) and a phase, while the RIS behavior is represented by a diagonal matrix, wherein the i -th element along the diagonal represents the phase shift introduced by the i -th RIS element. Indeed, the phase shift introduced by the RIS element

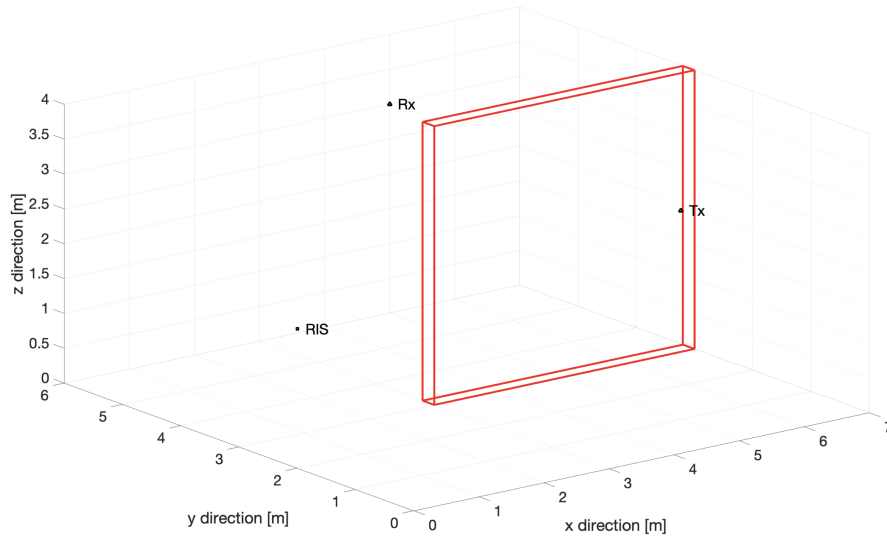


Figure 1: Simulated indoor scenario with a wall highlighted in red.

is a function of both the incident and reflected angles, allowing the impinging signal to be steered in a different direction. The phase shift is computed in accordance with the strategy outlined in [3], which assumes perfect knowledge of the channel. The RIS response is thus computed to maximize the SNR, which is expressed as:

$$\text{SNR} = \frac{\left| \sum_{i=1}^{N_{ele}} \alpha_i \beta_i e^{j(\phi_i - \theta_i - \psi_i)} \right|^2 P_T}{P_N} \quad (2)$$

The variables P_T and P_N represent the transmit and noise powers, respectively. The variables θ_i and ψ_i represent the channel phase between Tx/Rx and the i -th RIS element. The variables α_i and β_i denote the channel amplitude between Tx/Rx and the i -th RIS element. The variable ϕ_i denotes the phase introduced by the i -th element and is computed to maximize the SNR:

$$\phi_i = \theta_i + \psi_i \quad (3)$$

In accordance to this expression, two different cases are considering. In the former case a continuous phase values associated to each elements of the RIS are considered, and are labeled with *cRIS*. This means that the exactly analytical value obtained from (3) is associated. In the latter a theoretical 1-bit quantization of phase values is considered, *1q-RIS*. In this case a total reflection of the signal impinging on the surface is considered and the phase introduced by the i -th unit cell is equal to $\phi_i = \pi$ if $\frac{\pi}{2} < \phi_i < \frac{3}{2}\pi$, otherwise $\phi_i = 0$.

3 Performance Evaluation

This section presents an evaluation of the communication performance results, considering a range of P_T values from 0 to 40 dBm, with an increment of 1 dBm and a RIS of 64 elements spaced of $\lambda/2$. Figures 2(a)-2(b) depict the ABR and SNR for three scenarios, demonstrating an improvement in the presence of the RIS. The curve for the *wRIS* scenario demonstrates null values until reaching 34 dBm, after which it exhibits an upward trend. It should be noted that all null points on the ABR correspond to a negative SNR, wherein the attenuation introduced by the propagation is greater than the signal power.

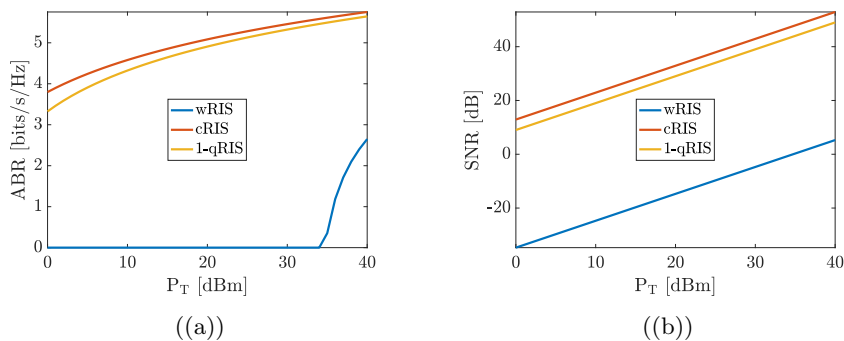


Figure 2: (a) Achievable Bit Rate and (b) Signal-to-Noise Ratio.

4 Conclusions

This report assesses the impact of RIS in indoor communication scenarios. It provides a concise overview of the channel model and RIS behavior, and offers an analysis of the resulting performance in terms of ABR and SNR. The results presented in the report were derived from a paper, subject to conference submission.

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