Reconfigurable Intelligent Surface-Assisted Beam Management for AI Signal Classification in mmWave Networks

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Millimeter wave (mmWave) communications are vulnerable to blockages and node mobility due to the highly directional signal beams. Reconfigurable intelligent surface (RIS) has emerged as a competitive solution to the blocking problem. However, due to the passive nature of the RIS, obtaining channel state information (CSI) for RIS-assisted mmWave communication systems is rather difficult. Automatic modulation classification (AMC) could improve the transmission efficiency of mmWave wireless communication systems, as it can adaptively select the most suitable modulation method according to the current communication environment, under the condition of unknown prior information, such as CSI, thus improving spectral efficiency and reducing the power consumption in NextG wireless communications systems. Deep learning (DL) has been widely used for AMC in sub-6 GHz wireless networks due to its capacity for feature learning directly on raw radio front-end data.

In this paper, we consider for the first time the implementation and experimental evaluation of existing DL methods for AMC based on convolutional neural network architectures that are trained and tested on raw IQ data collected from a software-defined mmWave radio testbed comprising a 4x4 mmWave wireless link that operates from 26.5 to 29.5 GHz and eight passive RIS with frequency coverage from 26 to 30 GHz and commonly used reflection angles. Figure 1 depicts the software-defined mmWave radio testbed We evaluate the performance of the DL-based AMC classifier for both LoS and NLoS scenarios with and without RIS. As the RIS are passive and operate with fixed angles, we implement a deep neural network (DNN)-based beam management framework that automatically adjusts the beams for both the mmWave transmitter and receiver, to enhance the performance of the AI signal classifier. The experiments are conducted in an indoor laboratory environment. The dynamic placement of the mmWave transmitter and receiver allows us to test the performance of the AI signal classifier models under different SNR conditions. Programmable re-configuration of the phase and amplitude of the sixteen channels at the transmitter and receiver enables evaluation of the optimized beam configuration that is selected by the proposed DNN framework.

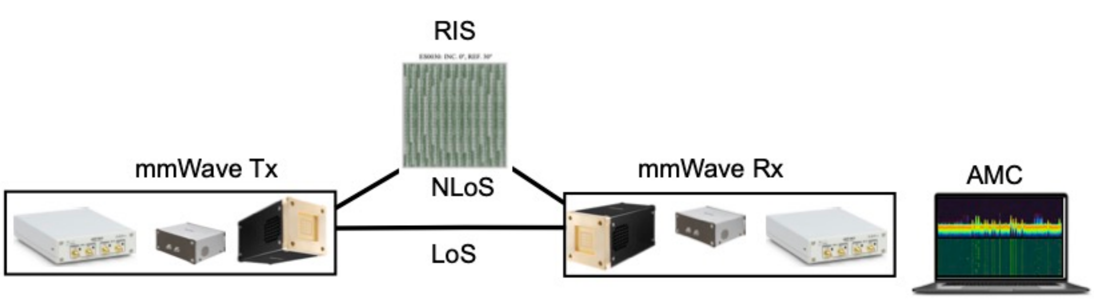

Figure 1: Software-defined mmWave radio testbed with RIS for AMC.