

将 8188 维复向量转化为 4 维实向量，从而实现数据降维和特征提取。

Each experiment contains multiple acquisitions, and each acquisition includes multiple CIR records. The transmitter sends a pilot signal with a 2047 b Pseudo-Noise code, and the receiver estimated the CIR data with 4 oversampling rates. Therefore, the CIR in each record is an 8188×1 complex vector as $\mathbf{H} = [h_1, \dots, h_{8188}]^T$. The other parameters for the test environments are shown in Table III.

Four attributes are extracted to measure the difference of CIR at different locations, which are the CG, channel phase (CP), peak power (PP), and root mean square (RMS) delay spread (DS) [52]. The CG can be calculated as

$$\hat{g}(dB) = 10 \log \sum_{j=1}^{8188} |h_j|^2 - G_t(dB) - G_r(dB), \quad (52)$$

where $G_t(dB)$ and $G_r(dB)$ represent the transmitter and receiver gains in dB, respectively. The CP reflects the degree of phase-frequency distortion, which is given as

$$\hat{\varphi} = \frac{1}{8188} \sum_{j=1}^{8188} \text{atan} \left(\frac{\text{imag}(h_j)}{\text{real}(h_j)} \right), \quad (53)$$

where $\text{real}(\cdot)$ and $\text{imag}(\cdot)$ denote the real and imaginary part, respectively. The PP is the maximum element of $|\mathbf{H}|^2$ as

$$\hat{p} = \max\{|\mathbf{H}|^2\}. \quad (54)$$

The RMS-DS measures the multi-path richness of a signal, which can be expressed as

$$\hat{\tau} = \sqrt{\sum_{j=1}^{8188} (\tau_j - \bar{\tau})^2 |h_j|^2 / \sum_{j=1}^{8188} |h_j|^2}, \quad (55)$$

where τ_j is the propagation time over the j -th path, and $\bar{\tau}$ denotes the mean delay.

A four-dimension vector that is formulated by formula (52) to (55) is constructed as the identifying signatures for each CIR data as

$$\mathbf{A}_t = [\hat{g}_t, \hat{\varphi}_t, \hat{p}_t, \hat{\tau}_t]. \quad (56)$$

对于 AAPlantD2_2GHz_TX1_vpol_internal_runF.mat, $G_t = 2.9$ dBi, $G_r = -3.8$ dBi, $\bar{\tau} = 477.7$ ns

对于 AAPlantD3_2GHz_TX2b_vpol_internal_run33.mat, $G_t = 2.9$ dBi, $G_r = -3.8$ dBi, $\bar{\tau} = 391.3$ ns

对于同一个发送端，两个接收端同时接收到了信号。将两个信号样本结合为一个样本，进而将 4 维特征转化为 8 维特征。