Validity of Kronecker model at 3.805GHz Indoor measurement 4 by 4 MIMO system

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Introduction

Multi-Input Multi-Output (MIMO) communication systems have become the center of public attention as alternative idea to overcome limitation of Single-Input Single-Output (SISO) [1]. There are three kind of analytic model on correlation-based: i.i.d. model, kronecker model and weichselberger model. In i.i.d. model, all elements of MIMO channel are uncorrelated, and we only need to know the variance of the transmit signal. When the channel is correlated, the Kronecker model and Weichselberger model are widely used for channel analysis. The spatial Tx and Rx correlation are assumed to be separable in Kronecker model which enforces a separable DoD-DoA spectrum in contrast to Weichselberger model [2].

Theoretical background

In the real estimation environment, we assume that transmit and receiver antenna are correlated. So, we can adapt measured antenna to kronecker model. In kronecker model, Tx and RX correlations are independents each other. Thus, the correlation matrix of kronecker model has been shown to be [3]

$$R_H = R_{Tx} \otimes R_{Rx} \tag{1}$$

Each Tx and Rx correlation are

$$R_{Tx} = E(H^H H) \tag{2}$$

$$R_{Rx} = E(HH^H) \tag{3}$$

Here, $\otimes$ is kronecker product. Since the Kronecker model is proposed for fading channel, this kind of Tx correlation tendency can be founded in NLOS scenario. We can know LOS/NLOS through validity of kronecker model from the measured Tx and Rx correlations. And we can represent the channel matrix H as following factorized form [3]

$$H = (R_{Rx})^{\frac{1}{2}} W (R_{Tx})^{\frac{1}{2}} \tag{4}$$

where W is independent and identically distributed (i.i.d) random matrix with zero mean and unit variance. Therefore, we can optimize receiver antenna if we know channel matrix H and transmit antenna. Channel matrix H is attained from 4 by 4 MIMO channel sounder.

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Measurement environment

The transmitter is composed of 4 dipoles, and antenna spacing is fixed to 1λ. The total transmitted power is 12 dBm, and transmit antennas are allocated in north even direction. In order to investigate the effect of antenna spacing and array direction (normal direction) on MIMO performance, the measurement is carried out with changing receiver's antenna spacing as 0.25, 0.5, 0.75, 1λ, and array direction as south, east-south, and east, respectively. Each single antenna is uniform and linearly allocated in antenna array (ULA) for all cases. In addition, the channel is measured in both Position 1 and Position 2.

The simple procedure of channel measurement method is applied to this measurement; Transmit antenna 1 and 2 send orthogonal signals, thus receiver can recognize the point of departure of received signal. Then, the elements of channel matrix are easily obtained.

Channel is measured at each 52 sub channel steps in 64 different points. The center frequency is 3.805 GHz, and antenna is designed for the target frequency. AOA estimation used for PAS measurement is acquired by beam-forming technology [4]. Fig. 1, shows the measurement environment.

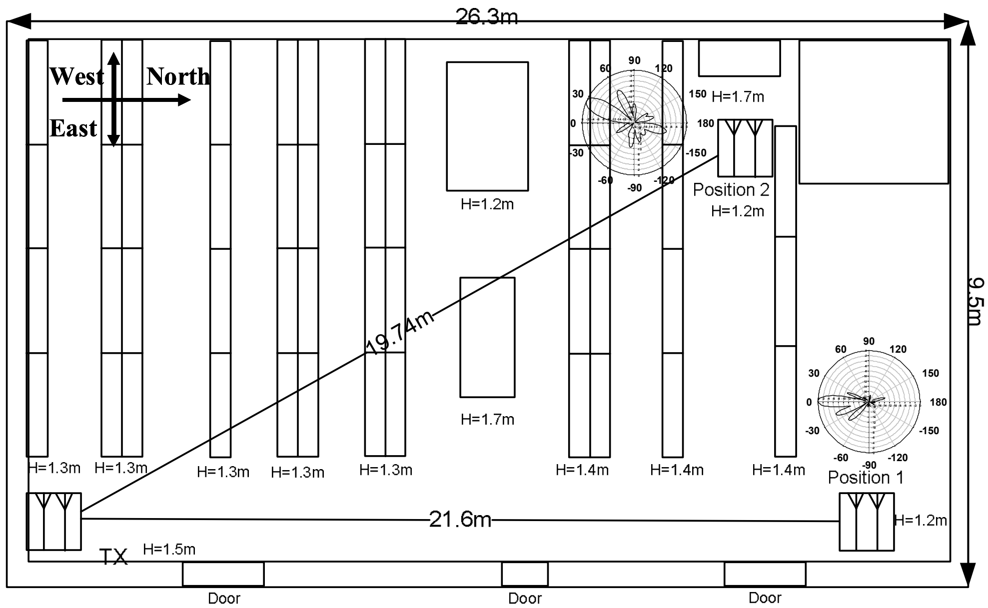

Fig. 1. 4X4 MIMO measurement environment

Conclusion and Discussion

Since the separation distance and direction of transmit antenna array are fixed and Tx correlation is not function of DoA of Rx antenna array, the Tx correlation should not be changed under the Kronecker assumption.

If the Kronecker channel model is valid, we can optimize the transmit antenna array and receive antenna array separately. Fig. 2 and Fig. 3 show the Tx and Rx correlation of Position 1 and 2, respectively. As shown in Fig. 2 and Fig. 3, the spatial correlation is not merely depended on separation distance if separation distance is longer than 0.5λ. Also, we can observe that the spatial correlation is dramatically depended on DoA and DoD of the channel with comparison to Fig. 2 and Fig. 3.

At the Position 2, Tx correlation is almost same for all cases, which is desired results under the Kronecker assumption (Fig. 3. (b)). However, in case of Position 1, relatively high variation of Tx correlation is observed (Fig. 2. (b)). Thus, we can infer that the position 1 and 2 denote the LOS and NLOS, respectively. Thus, we can induce that the optimization of transmit and receive antenna array can be achieved separately in case of NLOS environment and simultaneously in case of LOS environment. Channel analysis of LOS scenario may be adapted to Weichselberger model.

In addition, the Kronecker model is able to be applied to characterize channel environment. For example, we can determine whether the channel is LOS or NLOS by analyzing Tx correlation.

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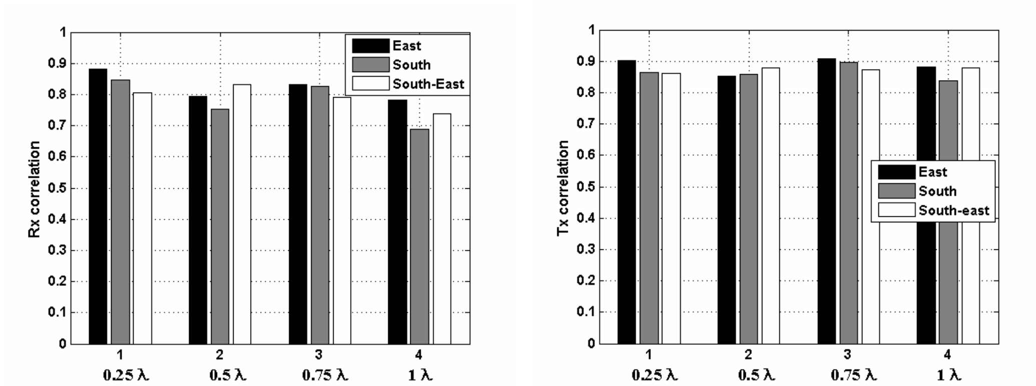
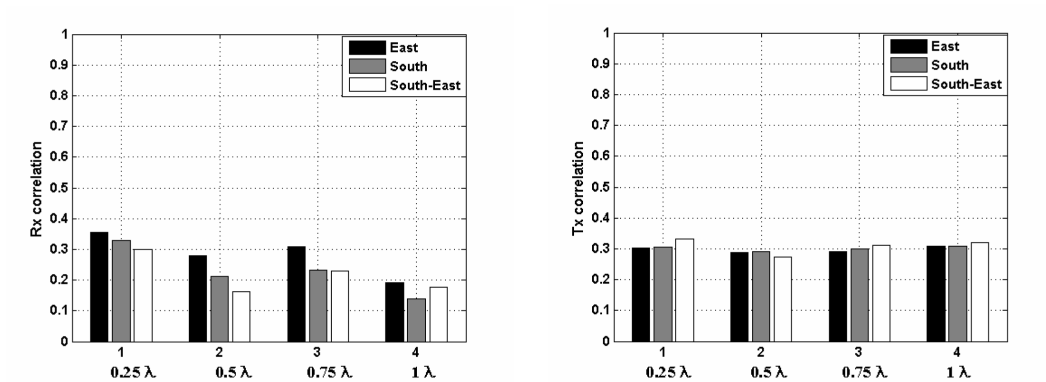


(a) Rx correlation (b) Tx correlation

Fig. 2. Tx and Rx correlations of LOS scenario (a) Rx correlation (b) Tx correlation



(a) Rx correlation (b) Tx correlation

Fig. 3. Tx and Rx correlations of NLOS scenario (a) Rx correlation (b) Tx correlation