ERPem
Edinburgh Research Partnership in Engineering and Mathematics
http://www.erp.ac.uk

Dual MIMO Ricean systems: From eigenstatistics to ergodic capacity upper bounds

Michail Matthaiou, David I. Laurenson and Cheng-Xiang Wang

Problem formulation

Assess the statistical and ergodic capacity properties of Ricean MIMO systems with two transmit and receive antenna elements (dual configurations).

Most studies dealing with MIMO systems elaborate on the common case of i.i.d Rayleigh fading where there is no dominant component in the communication link.

Motivation

Dual configurations are expected to be employed in the majority of future practical systems (e.g. hand-held devices) thanks to

- Small setup size
- Low implementation/complexity cost

Ricean fading models

- Include Rayleigh distribution as a special case
- Arise in a plethora of realistic propagation scenarios, e.g. macro-cells, vehicle-to-roadside etc.

Background

- Random matrix theory (complex non-central Wishart matrices and non-central quadratic forms)
- MIMO LoS-optimized configuration with orthogonal spatial subchannels.

MIMO channel model

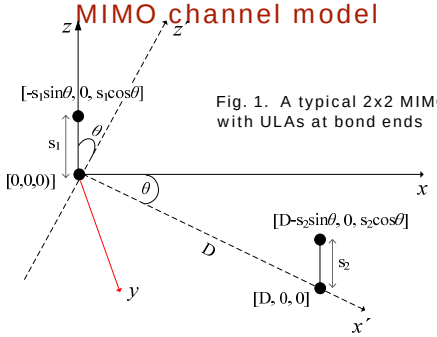

Fig. 1. A typical 2x2 MIMO system with ULAs at bond ends

Simplified criterion for spatial subchannel orthogonality and capacity maximisation

$$s_1 s_2 = \lambda \left(r + \frac{1}{2} \right) \frac{D}{\cos^2 \theta}, \quad r \in \mathbf{Z}^+$$

Main contributions

- Closed-form analytical expressions for the CDF and PDF of the condition number (ratio of the largest to the smallest eigenvalue) of a dual complex non-central Wishart matrix.

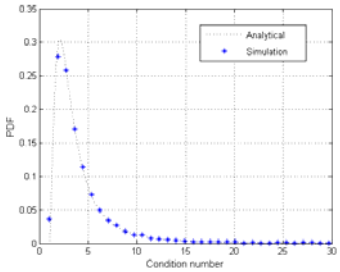

Fig. 2. PDF of the condition number as a truncated sum of polynomials. Excellent match between the explicit closed-form formulae and the Monte-Carlo simulator output.

- Novel simplified derivation of an upper bound on the ergodic capacity of dual MIMO Ricean systems, via a key power constraint.

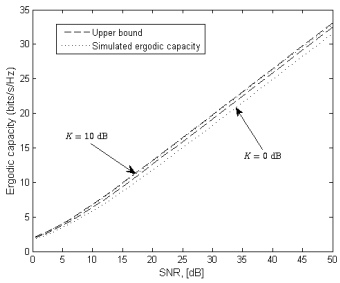

Fig. 3. Proposed tight upper bound and ergodic capacity as a function of the SNR. For LoS-optimized configurations, capacity increases with K-factor.

- Asymptotic tightness of the bound in the low and high-SNR regimes → novel analytical expressions derived.

Related publications

Journal papers

1. M. Matthaiou, D. I. Laurenson, and C. -X. Wang, "On analytical derivations of the condition number distributions of dual non-central Wishart matrices," in press *IEEE Trans. Wireless Commun.*, 2009.
2. M. Matthaiou, Y. Kopsinis, D. I. Laurenson, and A. M. Sayeed, "Ergodic capacity upper bound for dual MIMO Ricean systems: Simplified derivation and asymptotic tightness," *IEEE Trans. Commun., Jan. 2009, revised.*

Conference papers

1. M. Matthaiou, D. I. Laurenson, and C. -X. Wang, "Reduced complexity detection for Ricean MIMO channels based on condition number thresholding," *IEEE IWCMC 2008, Chania, Greece, Aug. 2008, pp. 988-993.*
2. M. Matthaiou, D. I. Laurenson, and C. -X. Wang, "Capacity study of vehicle-to-roadside MIMO channels with a line-of-sight component," IEEE WCNC 2008, Las Vegas, USA, Mar. 2008, pp. 775-779.

SIP
Signal & Image Processing