MIMO channel capacity in random media for communication through turbulence

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MIMO (multiple-input multiple-output) has received increasing attention in recent years because of the potential for increased channel capacity. There has also been increased interest in incorporating the physical scattering characteristics of the random medium in the formulations of the channel capacity. We present a general formulation of channel capacity for a random medium. First the channel transfer matrix from M transmitters to N receivers is expressed in terms of the stochastic Green's functions. The channel correlation matrix is then expressed in analytical form by the mutual coherence functions. The normalization is done by using Frobenius norm. It is noted that for a deterministic medium, the number of eigenvalues for the channel correlation matrix $\langle \mathbf{HH}' \rangle$ is equal to the smaller of M or N. But, in a random medium, the number of eigenvalues for $\langle \mathbf{HH}' \rangle$ is N and the trace of $\langle \mathbf{HH}' \rangle$ is MN where $\mathbf{H}$ is the normalized channel transfer matrix and $\mathbf{H}'$ is the adjoint of $\mathbf{H}$. The upper bound on the mean channel capacity is expressed using the eigenvalues of $\langle \mathbf{HH}' \rangle$, the normalization factor, and the noise power. If the random medium is a random distribution of particles such as rain, we use the mutual coherence function including the optical depth, albedo, and phase function. As an example, we calculate the channel capacity for 60 GHz propagation through rain and the eigenvalues and the channel capacity are calculated in terms of the SNR and the rain rate. If the random medium is turbulence, we use the Kolmogorov power spectrum and a structure constant. For 60 GHz propagation in turbulence, the eigenvalues are calculated as functions of the structure constant ranging from weak to strong turbulence. The eigenvalues increase slightly for longer propagation distance and larger element spacing. The capacity increases with SNR, but does not appear to depend on the turbulence strength.