Uses of Methods with Result Verification in the Context of MIMO Systems

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Technical simulations that take into account the underlying uncertainties have become indispensable in modern engineering. One possibility to deal with bounded uncertainty, for example, in parameters, is to employ methods with result verification such as interval analysis. In this way, it is possible not only to propagate such uncertainty through systems in a forward, deterministic manner, but also to verify that the result obtained using a computer definitely contains the true result of a simulation. In this contribution, we propose to use interval analysis to increase the reliability and to account for uncertainty in the context of the multiple-input multiple-output (MIMO) systems.

Placing multiple antennas at the transmitter and receiver sides has been shown to improve both the capacity and the integrity of a communication link. To model a frequency flat MIMO link consisting of n_{T} transmitting and n_{R} receiving antennas, a linear stochastic model [1]

$$\vec{y} = H \cdot \vec{a} + \vec{n}, \quad \vec{y}, \vec{n} \in \mathbb{C}^{n_{\mathrm{R}}},\ \vec{a} \in \mathbb{C}^{n_{\mathrm{T}}},\ H \in \mathbb{C}^{n_{\mathrm{R}} \times n_{\mathrm{T}}} \quad , \tag{1}$$

is widely employed. Here, $\vec{y}$ is the received data vector, $\vec{a}$ is the transmitted signal vector, $\vec{n}$ is the vector of the additive white Gaussian noise at the receiver side with the zero mean and the variance σ^2 in both real and imaginary parts, and H is the channel matrix. In practice, working with this model can be roughly divided into the steps shown in Figure 1.

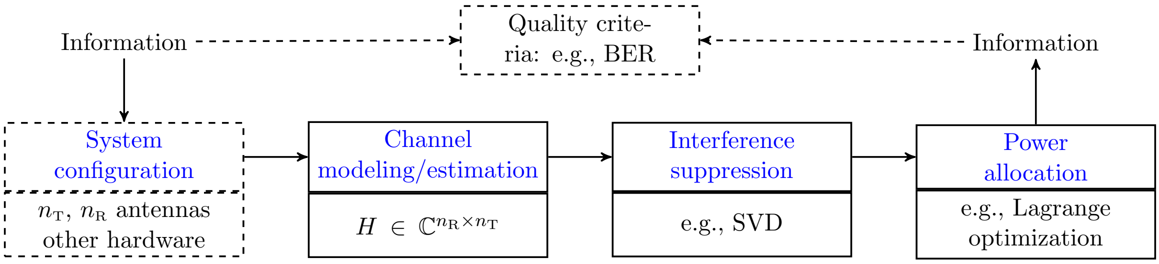

Figure 1: Modeling, simulation and optimization of a MIMO link

This entire process is influenced by several uncertain factors. For example, the matrix H is not known exactly (e.g., due to quantization errors or time variations of the channel). This can lead to faulty channel separation and subsequent failure to eliminate inter-antenna interference. Additionally, measurement errors or unknown noise power might complicate the optimization step.

In this contribution, we focus on uses of interval analysis at the stages of interference suppression and resource allocation. We show how correlated and uncorrelated MIMO systems can be optimized wrt. power if singular value decomposition (SVD) is employed at the stage of interference suppression. As an outlook, we compare the SVD to the so-called geometric mean decomposition (GMD), which can also be used for channel separation, from the point of view of the achievable bit error ratio (BER) and the influence of numerical errors and uncertainty.

References

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