# Three-dimension Channel Spatial Characteristics Emulation Based on Genetic Algorithm in a MIMO OTA Setup

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*Abstract* - **This paper presents a method to emulate three-dimension (3D) channel spatial characteristics which is based on genetic algorithm in a MIMO OTA setup. The proposed method applies genetic algorithm to 3D channel reconstruction, which controls the search process to obtain the global optimal solution adaptively. Simulation results show that genetic method gives higher reconstruction accuracy than convex optimal method. That is, using genetic algorithm can obtain better performance for emulating radio channel environment.**

*Index Terms* **—Channel emulation, MIMO OTA, anechoic chamber, spatial correlation, convex optimization, genetic algorithm.**

## 1. Introduction

Multiple-input multiple-output (MIMO) technology is an advanced technology that improves the performance of the communication system significantly in aspects of data rate and reliability. Various ways of standard testing methods of evaluating MIMO device performance are carried out by mobile manufacturers and cellular operators. MIMO over-the-air (OTA) technology can be a promising solution to evaluate MIMO device performance by creating required characteristics of radio propagation channel inside the anechoic chamber [1].

In [2], Pre-faded Synthesis (PFS) is discussed in detail in order to allocate appropriate probe weights so that the channel spatial characteristics can be reproduced in the test volume inside the anechoic chamber. Convex optimum method is introduced to find the proper weights to emulate the 3D spatial characteristics [3].

Genetic algorithm (GA) is one of the useful optimum tools to solve practical problems [4]. In this paper, genetic algorithm is used to emulate the 3D spatial characteristics in a MIMO OTA setup. The simulation results show that genetic algorithm is a better method compared to convex algorithm to obtain better performance for emulating radio channel environment.

## 2. Method

The spatial correlation is used as a figure of merit (FoM) to judge whether channel environment is reproduced accurately in the test area inside the anechoic chamber.

As simplified, the target spatial correlation can be determined as [5]:

$$\rho = \oint \exp\left[ jk\left(\vec{r_u} - \vec{r_v}\right) \bullet \vec{\Omega} \right] P(\Omega) d\Omega \tag{1}$$

where k is the wave number, $\vec{r_u}$ and $\vec{r_v}$ are two sample points at the opposite position of the surface of the test area in the anechoic chamber, $\vec{\Omega}$ is an unit vector denoting the solid angle $\Omega$, $P(\Omega)$ is the spherical power spectrum.

When calculate the target spatial correlation, sampling the test volume is needed to find the result of the target spatial correlation of all the sample points.

The basic idea of pre-faded signal synthesis [2] is that in order to reproduce realistic channel environment in the test volume inside the chamber accurately, it is necessary to allocate suitable probe weights to each of the probes in the chamber, respectively. The goal of allocating appropriate probe weights is to minimize the deviation between the target spatial correlation and the emulated spatial correlation.

The emulated spatial correlation related to probe weights can be calculated by the following discrete expression [5]:

$$\hat{\rho} = \sum_{m=1}^{M} \omega_m \exp\left[ jk\left(\vec{r_u} - \vec{r_v}\right) \bullet \vec{\phi_m} \right] \tag{2}$$

where $\omega_m$ is the $m$th probe weight, M is the total number of the probes, $\vec{\phi_m}$ is an unit vector denoting the position of the $m$th probe.

In order to find the appropriate probe weights, we discuss the following objective function to minimize the summation of the spatial correlation error [5]:

$$\min_{\omega} \left\| \hat{\rho}(\omega) - \rho \right\|_2^2 \tag{3}$$

where $\hat{\rho}$ is the simulated spatial correlation, $\rho$ is the target spatial correlation.

Genetic algorithm is a random global search algorithm which can select searching direction in an adaptive way based on the law of the biological evolution. It can deal with optimization problems in an accurate way. According to this contribution, the genetic algorithm has been utilized in 3D channel spatial correlation reconstruction to find the appropriate probe weights. In the operation process of the genetic algorithm, following parts are concluded:(a) Initialization (b) Fitness (c) Selection (d) Crossover (e) Mutation (f) Optimum solution

## 3. Simulation Results

In order to make a comparison of emulation results of 3D spatial characteristics between two algorithms, two scenarios are adopted for the target channel model. In scenario A, wrapped Gaussian is selected as both PAS (Power Azimuth Spectrum) and PES (Power Elevation Spectrum). While in scenario B, truncated Laplacian distribution is selected as both PAS and PES.

In scenario A, the spatial correlation error result of using convex method is described in Fig.1, while the spatial correlation error result of using genetic method is described in Fig.2. It can be seen that large part of the spatial correlation error of the test area is below 0.06 in Fig.2. While in Fig.1 half of the spatial correlation error is above 0.06. As shown in Fig.1 and Fig.2, the genetic method results in better spatial correlation error in scenario A compared to the convex method.

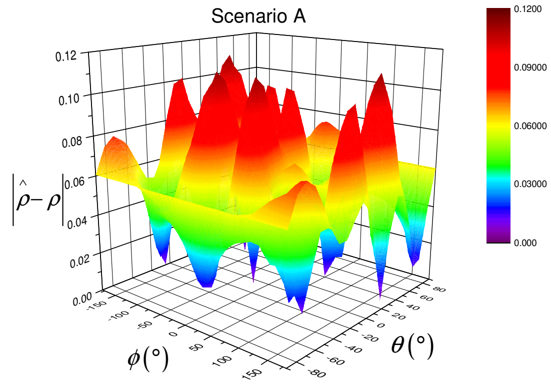


Fig.1. Spatial correlation error $\left|\hat{\rho}-\rho\right|$ in convex method

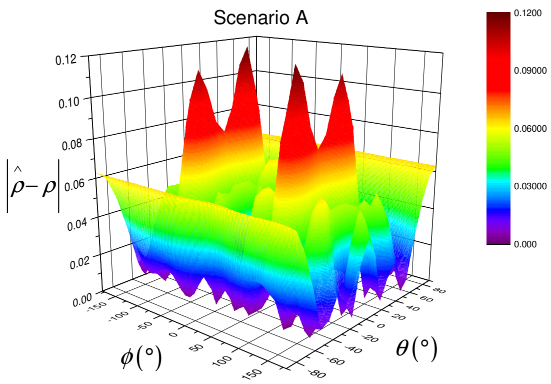


Fig.2. Spatial correlation error $\left|\hat{\rho}-\rho\right|$ in genetic method

In scenario B, most area of the spatial correlation error in Fig.3 is in the range of [0.03, 0.05]. While large part of the result in Fig.4 is under the value 0.03. That is, the spatial correlation error is reduced by using genetic method in emulating the channel spatial characteristics.

As a result, the genetic method results in higher reconstruction accuracy compared to the convex method.

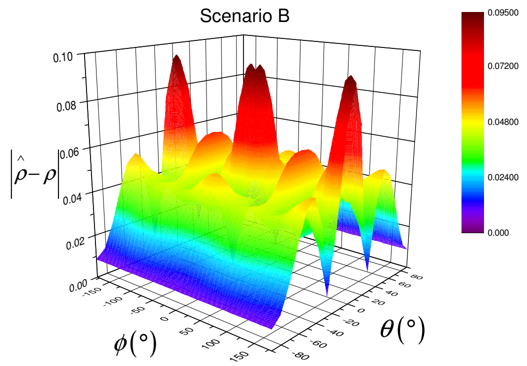


Fig. 3. Spatial correlation error $\left|\hat{\rho}-\rho\right|$ in convex method.

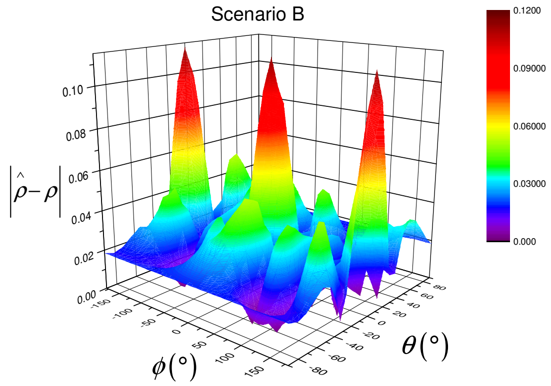


Fig. 4.Spatial correlation error $\left|\hat{\rho}-\rho\right|$ in genetic method

## 4. Conclusion

In this literature, three-dimension channel spatial characteristics is emulated by using genetic method. The emulation results show that genetic algorithm can obtain better performance for emulating radio channel environment.

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