CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S1008

Project Title

Demystifying Electromagnetic Coupling within Antenna Arrays: An Analytical Model to Approximate Radiative Coupling

Abstract

Objectives/Goals

Electromagnetic Coupling occurs as the presence and activity of one antenna, when in close proximity of another, can modify the received signals of the nearby antennas. Electromagnetic Coupling can be accounted for by using several techniques, such as with computational models. This project explores the possibility of an alternative program that is faster than the conventional standard, in hopes of bringing similar capabilities to a more mobile setting. The current programs that are used to simulate environments to obtain response data are very computationally heavy because they utilize the Method of Moments approach, which utilizes partial differentiation. Although they are accurate, these programs take time to generate results. Our goal going into this project was to create a mathematically simpler and faster way of estimating the responses of antennas in an antenna array while accounting for mutual coupling and to test our created model's accuracy.

Methods/Materials

The mathematical model we created uses linear algebra, along with coupling matrices and a multitude of equations such as the steering vector equation, to approximate the response of an antenna array with certain specifications. The program itself was written by us and run in Matlab. To determine the accuracy of our analytical model, we compared its output to that of a set of reference values from 4NEC2, a computationally heavy and accurate antenna modeling software program that utilizes the more complex Method of Moments approach (was developed by Lawrence Livermore National Laboratory).

Results

After conducting tests, we found that our model had about a 0.3 percent error on average from its reference for its generated results. In terms of time, our program generates results in, at most, 0.634 seconds faster than our reference program 4NEC2 (with a total runtime of about 5-10 seconds depending on exact specifications), when the number of elements being processed was 18 or less.

Conclusions/Discussion

This non-computationally intensive model can potentially be used instead of, or in addition to, more time-consuming or computationally heavy methods of calibrating an antenna array, especially on less powerful devices, such as FPGAs and microprocessors.

Summary Statement

We created an analytical model in Matlab to approximate electromagnetic coupling among antennas; our model requires less computational resources than existing models and posted a 0.3% error and ~.6 second faster run time than our reference.

Help Received

Wrote algorithm ourselves but received guidance from mentor Patrick Ellis (met through Science Internship Program at UCSC) for how to display results and improve aspects of our project.