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Design and Optimization of Antennas for Personal Communication Using Space Mapping Technology

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Introduction

This research-oriented project aims at the development and implementation of space-mapping (SM) optimization of antennas for personal communication. SM has been successfully applied in the optimization of microwave devices such as filters, matching circuits, multiplexer, etc, where coarse surrogate models are defined as physically based circuits. In antenna design and optimization, however, these physically based coarse models are either unavailable or do not result in good description of antenna circuits. Therefore, for antenna problems full wave (electromagnetic) coarse models, which are also computationally efficient, should be developed. Also, antenna optimization problems are typically multi-objective where the target response can simultaneously include several figures, e.g., antenna input impedance, bandwidth, radiation pattern, polarization, gain, efficiency, side lobe level, etc. Today's antennas are required to be of compact size for integration in personal communication unit (cell phone, laptop, etc). In addition, it is very desirable to have these antennas also possess reconfigurable (switchable) characteristics such as work bandwidth, antenna radiation pattern, antenna polarization.

Project goal

Implementation of SM optimization in design of antennas for personal communication

Project scope

Computer-aided design and optimization

- Full wave discrete and analytical coarse models of antenna radiator elements;
- Coarse hybrid surrogate models of antenna feed and control circuits for SM optimization;
- Fine hybrid models for simulation and validation of antenna circuits;
- SM algorithm for antenna optimization;

Antenna circuits

- Planar microstrip patch antennas and planar slot antennas on multilayer substrates;
- Planar antenna feed and matching network;
- Antenna control circuits for reconfigurable antennas;

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High Level Tasks

- Review antenna optimization techniques with respect to their applicability to design of planar antennas for personal communication. Points of interest: implemented models, algorithms, complexity of considered problems, the number of design variables, the number of figures in the optimized target response (dimension of the target response), consumed computational recourses, formulation of design specification.
- Describe requirements for the planar antennas including work bandwidth, antenna characteristics, dimensions, used materials, substrates etc.
- Define a list of design specifications typically imposed on antennas for personal communication.
- Define a set of test antenna configurations for SM model and algorithm testing, validation, and comparison. If applicable for a particular antenna configuration and in addition to configuration of antenna radiation elements, that can include feeding and matching circuits, control circuits, packages, etc.
- For chosen antenna configurations create and simulate fine models.
- For chosen antenna configurations develop EM-based coarse models using functional approximation, e.g., kriging.
- Test different SM optimization techniques such as output SM, input SM, their combinations. Evaluate performance of the coarse models relatively the fine models. Figures of interest include accuracy of the coarse models, CPU time and memory consumption relatively those of the fine models.
- Integrate the developed models, SM optimization algorithms, and EDA tools using Space Mapping Framework (SMF) software.
- Demonstrate the developed SM techniques by designing and optimizing a benchmark antenna circuits.

Outcomes

- The SM procedure for design of antennas for personal communication in the form of EDA models and Matlab codes working under SMF software.
- A number of optimal antenna designs.
- Reports on the developed SM technique at professional conferences, publications in conference proceedings;
- An MS thesis and the MS degree.

Skills acquired

- Knowledge of microwave engineering, antenna engineering, and working knowledge of planar antenna design;
- Working knowledge and hands on of EDA software (CST, FEKO, Agilent ADS, etc);
- Experience in scientific and engineering computing under Matlab;
- Experience in computer aided design and optimization under SMF