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Development of Optimization Algorithms for Smart Antennas

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Engineering Mathematics (Engineering Physics and Mathematics Department).

The work included in this thesis was carried out by the author at the Engineering Physics and Mathematics Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

Mathematical optimization is a new promising solving technique for the beamforming problem of smart antennas in various communication networks. The idea behind beamforming in smart antennas is the adjustment of the phase and amplitude of each antenna element in an antenna array to enhance the received signal and keep out unwanted interferers. On the other hand, mathematical optimization is the selection of a best element (with regard to some criteria) from some set of available alternatives to achieve a certain objective with or without a number of constraints that must be satisfied. Cognitive radio, an emerging new type of network, that has recently attracted a lot of research and that considers interference a challenging problem that needs to be solved meanwhile, smart antennas have proven high ability to minimize interference in many networks.

This thesis demonstrates the usage of mathematical optimization algorithms in beamforming for smart antennas of cognitive radio networks.

Mathematical optimization basics, types and methods of solution are illustrated and MATLAB simulations have been conducted to evaluate the performance of the current optimization solving techniques in beamforming for cognitive radio networks.

The analysis and simulation of beamforming in different cognitive radio networks are demonstrated. For single user and Multi-user cognitive radio networks, different beamforming models have been studied and performance of each is evaluated through simulation.

New algorithms for beamforming in cognitive radio are proposed by considering uncertainty in some of the problem inputs to ensure robustness of the solution; beside developing the solution to be more efficient.

The simulation is done for the new proposed model and performance is evaluated through comparison with other optimization models from literature.

Key words: Mathematical Optimization, Convex optimization, Non-convex optimization, Semdefinite Programming (SDP), Second Order Cone Programming (SOCP), Geometric Programming (GP), Smart Antenna, Beamforming, Cognitive Radio, Primary user, Secondary user, Multiple Input Single Output (MISO),. Multiple Input Multiple Output (MIMO), Antenna weights.

SUMMARY

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This thesis consists of a study for the optimization algorithms in beamforming for new emerging type of networks known by cognitive radio networks. Then simulating various beamforming algorithms used in literature for cognitive radio networks and Finally proposing new algorithm that is compared to the previous techniques by analysis and simulation.

The thesis is composed of six chapters together with the table of contents, the list of figures and tables, the references used in thesis.

The thesis contents are presented hereafter:

Chapter 1: presents the introduction to the thesis, the motivation of the thesis work, the problem statement, the objective of thesis work, the contribution of thesis work and ended by a brief survey to the contents of the thesis.

Chapter 2: introduces the main characteristics of smart antennas and specifically beamforming in cognitive radio networks. cognitive radio networks are introduced; principles, tasks and various cognitive behaviors. Then the main idea behind smart antennas and beamforming are explained; reasons behind adopting smart antennas, benefits, fundamentals of beamforming and finally beamforming in cognitive radio networks.

Chapter 3: concentrates on mathematical optimization types; it starts with introducing the basic idea, applications and solution of optimization problems in general. Secondly, explaining in detail different types of optimization problems through defining each problem and its different types of solution.

Chapter 4: concentrates on conventional beamforming models in cognitive radio networks. Beamforming models in single user cognitive

radio network are explained, solutions are presented and simulation results are discussed. Furthermore, multi user cognitive radio networks are studied; where different beamforming models and solutions are evaluated through simulations.

Chapter 5: is introducing modifications in some beamforming models for cognitive radio. Firstly, modifications are done on Multiple Input Single Output (MISO) cognitive radio system. Secondly, modifications are done on Multiple Input Multiple Output (MIMO) cognitive radio system. In each proposed model the system model and mathematical model are discussed and analyzed and finally the simulation results of each model are presented.

Chapter 6: presents the conclusion and recommendations for future work.

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