AIN SHAMS UNIVERSITY
FACULTY OF COMPUTER & INFORMATION SCIENCES
DEPARTMENT OF COMPUTER SCIENCE

Using Parallel Computing to Speed-up Beam Forming Patterns for Real Time Applications

A Thesis Submitted to the Department of Computer Science, Faculty of Computer and Information Sciences, Ain Shams University, in Partial Fulfilment of the Requirements for the Master Degree of Computer and Information Sciences

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Abstract

The scientific community is still interested in heuristic techniques and optimization algorithms that could be applied in complex problems such as adaptive antenna beam-forming problem. This thesis presents an empirical study of solving the problem of adaptive antenna beam-forming using Particle Swarm Optimization (PSO), Central Force Optimization (CFO) and Gravitational Search Algorithm (GSA) using Open Multi-Processing (Open-MP) or using Compute Unified Device Architecture (CUDA) which then applied on a Graphics Processing Unit (GPU). The PSO, CFO and GSA are well known alternatives for global optimization based on a nature-inspired Heuristic. Extensive experimentations were applied to compare their performance through a number of case studies. PSO showed to have good performance, low computational complexity, few parameters and gives good results. On the other hand, CFO has a higher computational complexity but it gives better results. Furthermore, although GSA has the same idea of CFO, it performs different computations and hence outperforms the other optimization techniques for the adaptive beam-forming problem. It is found that the resulting beam-patterns optimized by the PSO, CFO or GSA required a large processing time which is not acceptable for on line applications. Hence, the demand for a parallel solution that accelerates these computations is considered. Therefore, a parallel version of PSO, CFO and GSA is proposed and implemented using Open-MP or using CUDA which then applied on a GPU. The comparison is presented to show how the parallel version of the PSO, CFO and GSA outperforms the sequential one, thus an online

procedure is available for time-critical applications such as in adaptive beam-forming applications.

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Introduction

CHAPTER 1

Introduction

1.1. Motivation and problem Statement

Smart antenna systems have been widely considered to provide interference reduction and improve the capacity, data rates, and performance of wireless mobile communication. Smart antenna arrays with adaptive beam-forming capability are very effective in the suppression of interference and multipath signals [1] [2]. The techniques of placing nulls in the antenna patterns to suppress interference and maximizing their gain in the directions of desired signals have received considerable attention in the past and are still of great interest using evolutionary algorithms such as genetic algorithm (GA) and particle swarm optimization (PSO) algorithm [3] [4].

For adaptive arrays using space division multiple access (SDMA), the optimal radiation pattern is synthesized using recent different optimization techniques such as Central Force Optimization (CFO), and Gravitational Search Algorithm (GSA). The algorithms are applied to a 24-element uniform circular array (UCA) to synthesize the array beam-pattern by optimizing the complex excitations values, amplitudes and phases of the adaptive array elements. The antenna elements consist of vertical (z-directed) half-wave dipole elements equally spaced in the x-y plane along a circular ring, where