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Evolutionary-Based Optimization Techniques for Inverse Scattering - A Review

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The use of stochastic global optimizers has had a non-negligible impact on several areas of research and industry and they have been effectively applied to several problems in engineering and sciences [1]. Thanks to the availability and growing of computational resources with the large diffusion of modern computers, optimization techniques based on Evolutionary Algorithms (EAs) have received a wide attention because of their attractive features. As a matter of fact, EAs are hill-climbing algorithms and do not require the differentiation of the cost function, which is a "must" for gradientbased methods. They are based on stochastic iterative procedures where a pool of trial solutions is used to sample the solution space at each iteration thus improving the search capability as compared to single-agent techniques (e.g., Simulated Annealing). A-priori information can also be easily introduced in terms of additional constraints on the actual solution or the boundaries of the solution space. Moreover, they can directly deal with real values as well as with coded representations of the unknowns (e.g., binary coding). Their main drawback (i.e., the convergence rate) has been also further contrasted by exploiting their implicit and explicit parallelism thanks to modern computer clusters [2].

Since EAs have shown to effectively deal with complex functionals characterized by large, complex, and nonlinear problems, they have been also profitably applied to the solution of electromagnetic inverse scattering problems for microwave imaging [3][4]. The class of Genetic Algorithms (GAs) have been the first population-based EAs used as inversion procedures for electromagnetic diagnostic problems. Several versions of GAs have dealt with the shape reconstruction of perfectly conducting objects as well as the reconstruction of penetrable scatterers [5]. Successively, other evolutionary-based algorithms has been introduced to overcome the main drawback of GAs, namely the low convergence rate. In such a framework, the Differential Evolution (DE) algorithm [6][7] has been used for the optimization of real-coded unknowns. Moreover, approaches inspired by the cooperative behaviour of swarms have been used. More specifically, the Particle Swarm Optimizer (P SO) [8] and the Ant Colony Optimizer (ACO) have also been successfully applied [3]. In order to exploit the high converge rate of gradient-based minimization techniques, several hybrid approaches has been implemented to improve the efficiency of EAs [9], as well.

In such a contribution, a review of the evolutionary-based techniques for inverse scattering problems is presented pointing out potentialities and limitations of state-of-the-art solutions also discussing the current trends of the research in such a field.

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