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Novel Techniques for Communication Engineering Problems

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Abstract

Nature inspired meta-heuristic based approaches are likely to dominate the conventional numerical and deterministic techniques. This paper presents a short review on the applications of the evolutionary computing tools and bio-inspired techniques for solving communication engineering problems. Primarily, the design issues of electromagnetic systems and techniques in image processing are summarised and the discussion is confined to these areas only.

Keywords: Communication engineering problems; Multi-objective; Thresholding; Electromagnetics

Introduction

Meta-heuristic approaches are not problem specific or otherwise treated as problem independent techniques. Hence the take the credit of providing solutions which are sustainable as well as affordable with high degree of reliability and modularity. A design problem typically takes the design variables as inputs which define the dimension of the problem and the solution space. The objectives define the desired response of the system along with constraints. The block diagram governing this process is as shown in Figure 1.

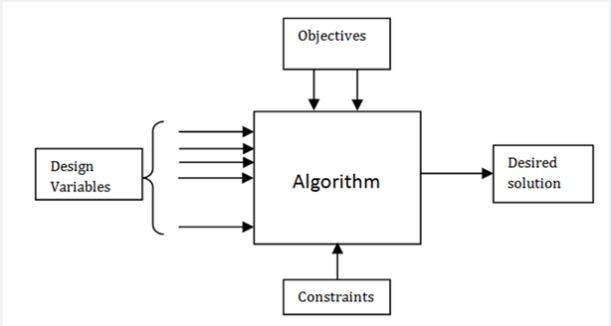

Figure 1: Description of a design problem.

In many cases, the problems are multi-variable and Multi-Objective (MO). However, in most of the cases, the MO problems are converted to single objective with weighted functions for simplicity where as the actual solution lies in the MO treatment. While transforming the MO problems to single objectives the corresponding objective values may not be of same type and scale. Hence specific normalization should be incorporated in order to establish unbiased approach. The most significant part of solving a design problem using EC techniques is the problem statement which transforms the synthesis issue in to an optimization, prediction, forecasting, classification or modelling problem. Globally any engineering problem can fit to one of this category [1].

Application areas

Image processing

In image processing, these EC techniques are widely used for de-noising, watermarking, compression, restoration, enhancement and analysis. Particularly capable of performing feature extraction, classification, clustering and pattern recognition. The technique uses adaptive thresholding in wavelet transformation of the image. The threshold distribution is determined by the population based EC technique. The objective function computes the cost in terms of the image metrics like peak signal to noise ratio, structural similarity index and mean square error. Generally the process should necessarily have the knowledge of the source image to model the channel where the image gets corrupted. In such cases, training images are first used, because a copy of these in its original un-corrupted form is available with the processing end. However, intelligent methods based on adaptive non-local means with no 'noise-free' image as reference are proposed using these techniques [2].

Electromagnetics

In the field of electromagnetic, these evolutionary computing tools are applied to antenna design problems. The design problems are classified as either modelling or optimization. They either involve in designing the radiating system for desired radiation characteristics or optimizing one of the characteristics with respect to other. The concept of evolvable antennas is almost made possible with these non-conventional techniques where the antenna design is automated according to the requirements of the environment and applications like space technology. On the other side, the antenna arrays are capable of controlling radiation pattern for desired main beam-width and side-lobe level with proper modifications of geometrical and electrical properties of the array. An antenna array synthesis problem involves in determining weights for the geometrical properties like spacing (d) between elements or electrical properties like current excitation and phase excitation that produces desired radiation pattern. Many conventional numerical techniques which are derivative based are proposed for such array synthesis. These conventional techniques have tendency to stuck in the local minima as most of them are local search methods. Moreover, the final solution is dependent on the initial solution. If the initial value is chosen such that its solution lies in the region of solution space that is close to local minima, then the local search gives the best of poor local solution that are available and often fail to handle multimodal or multi objective problems. In the recent past several meta-heuristic algorithms are proposed to overcome the computational complexity and its drawback. These algorithm are versatile and also robust [3,4].

Conclusion

From the above discussion it is possible conclude that almost any design and synthesis problem can coined as modelling or optimization problem and can be solved using EC techniques. These techniques are simple with no complex computation involved and are efficient in providing global solution with capability to handle multi-modal problems. These techniques are the latest trends in problem solving in the fields of image processing and electromagnetics. From the design point of view, as the approach is meta-heuristic, it is possible to visualize the problems with a common or categorised perspective.

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