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APPROXIMATE MODELS FOR CONSTRAINT FUNCTIONS IN EVOLUTIONARY CONSTRAINED OPTIMIZATION

Sanghoun Oh[1], Yaochu Jin[2] and Moongu Jeon[1,*]

[1]School of Information and Communications
Gwangju Institute of Science and Technology
1 Oryong-dong, Buk-gu, Gwangju 500-712, Korea
oosshoun@gist.ac.kr; *Corresponding author: mgjeon@gist.ac.kr

[2]Department of Computing
University of Surrey
Guildford, Surrey GU2 7XH, United Kingdom
yaochu.jin@surrey.ac.uk

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Abstract. *Many real-world scientific and engineering problems are constrained optimization problems (COPs). To solve those COPs, a variety of evolutionary algorithms have been proposed by incorporating various constraint handling techniques. However, many of them are not able to achieve the global optimum due to the presence of highly constrained, isolated feasible regions in the search space. To effectively address the low ratio of feasible regions in the search space, this paper presents a genetic programming based approximation approach in combination with a multi-membered evolution strategy. In the proposed constraint-handling method, we generate an approximate model for each constraint function with an increasing accuracy, from a linear-type approximation to a model that has a complexity similar to the original constraint functions, thereby manipulating the complexity of the feasible region. Thanks to this feature, our constrained evolutionary optimization algorithm can achieve the optimal solution, effectively. Simulations are carried out to compare the proposed algorithm with the state-of-the-art algorithms for handling COPs on 13 benchmark problems and three engineering optimization problems. Our simulation results demonstrate that the proposed algorithm is comparable to or better than the state-of-the-art on most test problems, and clearly outperforms many algorithms in solving the engineering design optimization problems.*
Keywords: Genetic programming, Approximate constraints, Synthesized constraints, Stochastic ranking selection, Evolution strategy

1. **Introduction.** Evolutionary algorithms (EAs) have been widely employed to solve COPs, which are often seen in solving real-world optimization problems [1, 2, 3]. Without loss of generality, the COPs can be defined as a minimization problem subject to equality and/or inequality constraint functions as follows:

$$\text{minimize} \quad f(\vec{x}), \quad \vec{x} = (x_1, \cdots, x_n) \in \mathcal{R}^n \tag{1}$$

$$\text{subject to} \quad h_i(\vec{x}) = 0, \quad i = \{1, 2, \cdots, r\} \tag{2}$$

$$g_j(\vec{x}) \le 0, \quad j = \{r+1, \cdots, m\}, \tag{3}$$

where $\mathcal{R}^n$ is n-dimensional search spaces; each design variable is positioned within the parametric constraints of $\underline{x}_i \le x_i \le \overline{x}_i$, $i = \{1, \cdots, n\}$; $f(\vec{x})$ is an objective function; $h_j(\vec{x})$ and $g_j(\vec{x})$ are r equality constraints and $m-r$ inequality constraints, respectively.

Conventional evolutionary approaches for solving COPs often suffer from the highly constrained design spaces, particularly those with separated, small feasible regions. For