An Efficient Constraint Handling Approach for Optimization Problems with Limited Feasibility and Computationally Expensive Constraint Evaluations

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ABSTRACT
Existing optimization approaches adopt a full evaluation policy, i.e. all the constraints corresponding to a solution are evaluated throughout the course of search. Furthermore, a common sequence of constraint evaluation is used for all the solutions. In this paper, we introduce a scheme of constraint handling, wherein every solution is assigned a random sequence of constraints and the evaluation process is aborted whenever a constraint is violated. The solutions are sorted based on two measures i.e. the number of satisfied constraints and the violation measure. The number of satisfied constraints takes a precedence over the amount of violation. We illustrate the performance of the proposed scheme and compare it with other state-of-the-art constraint handling methods within a framework of differential evolution. The results are compared using g-series test functions for inequality constraints. The fitness of a solution is determined as follows:

\[ \text{fitness}(\xi) = \begin{cases} f(x), & x \in \mathbb{R}^n \\ c_i, & i = 1, 2, ..., m \end{cases} \] (2)

where \( c_i \) is the constraint violation measure of the \( m \) number of constraints. The equality constraints are transformed into a set of inequalities as \( |h_i(x) - \delta| \leq 0 \) (assuming \( \delta \) is small positive quan-

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ACM 978-1-4503-1964-5/13/07.
3. EXPERIMENTAL RESULTS

The above section illustrated the principles of constraint sequencing and partial evaluation. In this section we objectively evaluate its performance on CEC-2006 [5] benchmarks. We also include the results obtained by using stochastic ranking (SR) [6], self-adaptive penalty (SP) [7], superiority of feasibility (SF) [8] and epsilon constraint (EC) [9] within the same framework of DE. Results based on performance profile are included for a more objective comparison.

A population size of 50 is used for all the problems and the results are computed based on 30 independent runs. A fixed value of CR = 0.9 and F = 0.5 have been set for all the cases resulting in the number of function evaluations (i.e. NFEs) of 4800 * (N * m), where N is the size of the population and m is the number of constraints.

In this experiment, we observe how quickly a feasible solution appears in the population—the function evaluation to reach a feasible solution and the computational time required to achieve the feasible solution. A performance profile [10] is computed for a more objective comparison between the strategies. The results clearly indicate the superiority of DE-CS over other strategies in terms of NFEs and computational time. Figure 1 shows the value of $\rho(\tau)$ for $r_{0,s} \leq \tau$ of the normalized performance ratio [10] i.e. (a) the number of function evaluation (b) computational time. One can observe from the figure that DE-CS outperforms with other strategies in terms of both.

**Figure 1: Performance profile of DE-CS and others**

4. CONCLUSION

In this paper, a scheme of constraint handling has been introduced within the framework of differential evolution utilizing the concepts of partial evaluation and constraint sequencing. The performance of the algorithm is subsequently assessed on 11 well known constrained single objective optimization benchmarks. The results on the test problems clearly indicate that the approach is computationally efficient and better than existing strategies for constraint handling.

5. ACKNOWLEDGEMENT

The second author would like to acknowledge the support of Future Fellowship offered by the Australian Research Council.

6. REFERENCES