Infeasibility and structural bias in Differential Evolution
EXTENDED RESULTS

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Abstract

This supplement contains the full set of results referred to in the main publication “Infeasibility and Structural bias in Differential Evolution”. The paper (1) briefly outlines experimental setup; (2) presents graphical results on the distributions of the percentage of corrections per DE configuration for all examined combinations of population size, correction strategy, and settings of $F$ and $CR$; (3) presents the distribution of final best solutions per DE configuration for each combination of population size and correction strategy. All conclusions are given in the main paper.

Keywords: structural bias, algorithmic design, differential evolution, population-based algorithms, optimisation

This document contains the full set of results, complementing the work published in the main article.

Indications on how to interpret the results are given in this document, however the full details of experimental pre-requisites, motivation and setup are available in the main article. Nevertheless, in case useful, a brief summary of the experimental setup is provided next.

The eight DE schemes under investigations are:

- DE/rand/1/bin;
- DE/rand/1/exp;
- DE/rand/2/bin;
- DE/rand/2/exp;
- DE/best/1/bin;
- DE/best/1/exp;
- DE/current-to-best/1/bin;
- DE/current-to-best/1/exp;

Each of these schemes is tested independently with three different correction strategies, namely:

- Penalty correction;
- Saturation correction;

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• Toroidal correction;

thus totalling $8 \times 3 = 24$ different configuration variants to study. To look for structural biases, each configuration was run 50 times independently on the test problem $f_0$ (which was introduced in [2],[1]), with dimension $n = 30$, and a computational budget of $10000 \times n = 300000$ fitness evaluations per run.

To understand the impact on increasing population sizes, each one of the 24 variants was studied with $NP \in \{5, 20, 100\}$ (i.e. $24 \times 3 = 72$ cases). As for control parameters, values of $F$ and $CR$ are specific to the test and are specified in each of the relevant subsections.

Extended Results are thorough and organised as follows:

• Section 1 reports results on structured bias for each one of 72 cases under investigation;
• Section 2 shows results for “One Tailed Normal” correction;

1. Results on structural bias

This section contains eight figures, i.e. one per DE scheme, each showing results for the nine possible configurations (i.e. 9 subfigures) with population sizes $NP \in \{5, 20, 100\}$ and correction strategy being either penalty, saturation, or toroidal.

Each subfigure depicts the final populations from 50 runs in parallel coordinates, as explained in the main article, as well as in [2],[1]. The optimisation process of $f_0$ at $n = 30$ was carried out with a computation budget of $10000 \times n = 20000$ fitness function calls and fixed (chosen) control parameters $F = 0.1$ and $CR = 0.2$.

The figures are arranged as follows:
• Figure 1 displays results for DE/rand/1/bin;
• Figure 2 displays results for DE/rand/1/exp;
• Figure 3 displays results for DE/rand/2/bin;
• Figure 4 displays results for DE/rand/2/exp;
• Figure 5 displays results for DE/best/1/bin;
• Figure 6 displays results for DE/best/1/exp;
• Figure 7 displays results for DE/current-to-best/1/bin;
• Figure 8 displays results for DE/current-to-best/1/exp.
Figure 1: Results for DE/rand/1/bin.
Figure 2: Results for DE/rand/1/exp.
Figure 3: Results for DE/rand/2/bin.
Figure 4: Results for DE/rand/2/exp.
Figure 5: Results for DE/best/1/bin.
Figure 6: Results for DE/best/1/exp.
Figure 7: Results for DE/current-to-best/\bin.
Figure 8: Results for DE/current-best/1/exp.
2. Further results on structural bias with One Tailed Normal correction

This section contains four figures, displaying results for all DE variant under consideration, this time equipped with the One Tailed Normal correction strategy (described in the main article).

Figure 9 shows 6 subfigures, comprising each combination of the DE/rand/1/bin and De/rand/1/exp variants, see Section 1, and the three population sizes \( NP \in \{5, 20, 100\} \).

Similarly, Figure 10 shows 6 subfigures, representing all pairings of the two DE/rand/2 variants (i.e. with binomial exponential crossover respectively) and the three population sizes \( NP \in \{5, 20, 100\} \), and so on with Figure 11 for DE/best/1/bin and DE/best/1/exp, as well as Figure 12 for DE/current-to-best/1/bin and DE/current-to-best/1/exp.

Each subfigure depicts the final populations from 50 runs in parallel coordinates, as explained in the main article, as well as in [2, 1]. Each run, as usual on objective function \( f_0 \) with dimension \( n = 30 \), was carried out with a budget of \( 10000 \times n = 300000 \) fitness function calls and fixed (chosen) control parameters \( F = 0.1 \) and \( CR = 0.2 \).
Figure 9: Results for $\text{DE/rand/1/bin}$ and $\text{DE/rand/1/exp}$ with One Tailed Normal correction.
Figure 10: Results for DE/rand/2/bin and DE/rand/2/exp with One Tailed Normal correction.
Figure 11: Results for DE/best/1/bin and DE/best/1/exp with One Tailed Normal correction.
Figure 12: Results for DE/current-to-best/1/bin and DE/current-to-best/1/exp with One Tailed Normal correction.
Figure 13: Example of interpolated surfaces of average percentage and standard deviations of corrections for DE/best/1/bin with toroidal correction for three population sizes for various values of $F$ (vertical axis $[0, 1]$) and $Cr$ (horizontal axis $[0, 1]$). For full explanation about axes and colours, see the main article.
References
