Publications of Georg Tennigkeit

This document lists all peer-reviewed publications of Georg Tennigkeit, Chair for Algorithm Engineering, Hasso Plattner Institute, Potsdam, Germany. This listing was automatically generated on February 25, 2024. An up-to-date version is available online at hpi.de/friedrich/docs/publist/tennigkeit.pdf.

Journal articles

[1] Friedrich, T., Kötzing, T., Radhakrishnan, A., Schiller, L., Schirneck, M., Tennigkeit, G., Wietheger, S., Crossover for Cardinality Constrained Optimization. In: *ACM Transactions on Evolutionary Learning and Optimization* 3, pp. 1–32, 2023.

To understand better how and why crossover can benefit constrained optimization, we consider pseudo-Boolean functions with an upper bound B on the number of 1-bits allowed in the length-n bit string (i.e., a cardinality constraint). We investigate the natural translation of the OneMax test function to this setting, a linear function where B bits have a weight of $1+1/n$ and the remaining bits have a weight of 1. Friedrich et al. [TCS 2020] gave a bound of $\Theta(n^2)$ for the expected running time of the (1+1) EA on this function. Part of the difficulty when optimizing this problem lies in having to improve individuals meeting the cardinality constraint by flipping a 1 and a 0 simultaneously. The experimental literature proposes balanced operators, preserving the number of 1-bits, as a remedy. We show that a balanced mutation operator optimizes the problem in $O(n \log n)$ if $n - B = O(1)$. However, if $n - B = \Theta(n)$, we show a bound of $\Omega(n^2)$, just as for classic bit mutation. Crossover together with a simple island model gives running times of $O(n^2/\log n)$ (uniform crossover) and $O(n\sqrt{n})$ (3-ary majority vote crossover). For balanced uniform crossover with Hamming-distance maximization for diversity we show a bound of $O(n \log n)$. As an additional contribution, we present an extensive analysis of different balanced crossover operators from the literature.

Conference papers

[2] Friedrich, T., Kötzing, T., Radhakrishnan, A., Schiller, L., Schirneck, M., Tennigkeit, G., Wietheger, S., Crossover for Cardinality Constrained Optimization. In: *Genetic and Evolutionary Computation Conference (GECCO)*, pp. 1399–1407, 2022. Best Paper Award (Theory Track).

In order to understand better how and why crossover can benefit optimization, we consider pseudo-Boolean functions with an upper bound B on the number of 1s allowed in the bit string (cardinality constraint). We consider the natural translation of the OneMax test function, a linear function where B bits have a weight of $1 + \varepsilon$ and the remaining bits have a weight of 1. The literature gives a bound of $\Theta(n^2)$ for the (1+1) EA on this function. Part of the difficulty when optimizing this problem lies in having to improve individuals meeting the cardinality constraint by flipping both a 1 and a 0. The experimental literature proposes balanced operators, preserving the number of 1s, as a remedy. We show that a balanced mutation operator optimizes the problem in $O(n \log n)$ if $n - B = O(1)$. However, if $n - B = \Theta(n)$, we show a bound of $\Omega(n^2)$, just as classic bit flip mutation. Crossover and a simple island model gives $O(n^2/\log n)$ (uniform crossover) and $O(n\sqrt{n})$ (3-ary majority vote crossover). For balanced uniform crossover with Hamming distance maximization for diversity we show a bound of $O(n \log n)$. As an additional contribution we analyze and discuss different balanced crossover operators from the literature.