Where should Children be Generated by Crossover Operator on Function Optimization ?

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1 Trimodal Distribution Crossover

For the floorplan design problem, one of combinatorial optimization problems, we proposed "Genetic algorithm with Search area Adaptation (GSA)" [Someya 1999]. The crossover used in GSA generates children in the middle of the parents as possible, and the approach has shown good performance. We transfer this idea to function optimization. We propose "Trimodal Distribution Crossover (TMX)" to confirm if the approach of the GSA is effective for function optimization.

TMX is designed to search in the middle of the parents with high priority since parents have been already survived among the other individuals close to each of them. We believe that parents need not compete again with the others in the next generation. Figure 1 shows an example of TMX, in which the parents are placed at (1, 1) and (-1, -1). Children, $\vec{C}_1$ and $\vec{C}_2$, are determined by three parents as follows:

$$\vec{C}_1 = \vec{m} + t_1\vec{e}_1 + \sum_{k=2}^{n} z_k\vec{e}_k \ ,$$
$$\vec{C}_2 = \vec{m} - t_1\vec{e}_1 - \sum_{k=2}^{n} z_k\vec{e}_k \ ,$$

where $\vec{m} = (\vec{P}_1 + \vec{P}_2)/2$, $\vec{P}_1$ and $\vec{P}_2$ are parent vectors. $\vec{e}_1 = (\vec{P}_2 - \vec{P}_1)/|\vec{P}_2 - \vec{P}_1|, \vec{e}_k$ are the orthogonal unit vectors. n is the dimension. $z_k \sim N(0, \sigma_2^2)$ are normally distributed random numbers. $\sigma_2 = \beta d_2/\sqrt{n}$. d_2 is the distance of the Parent3 from the line connecting Parent1 and Parent2. t_1 is a random number based on the following function, $t(x, \sigma_1, h)$:

$$t(x, \sigma_1, h) = \frac{1}{\sqrt{2\pi}\sigma_1} e^{-\frac{x^2}{2\sigma_1^2}} \times \frac{(x^2 - h^2)^2}{h^4(48\alpha^4 - 8\alpha^2 + 1)},$$

where h is the half distance between Parent1 and Parent2. $\sigma_1 = 2\alpha h$. α, β are constants.

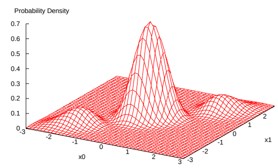

Figure 1: Probability density of TMX on a two-dimensional function.

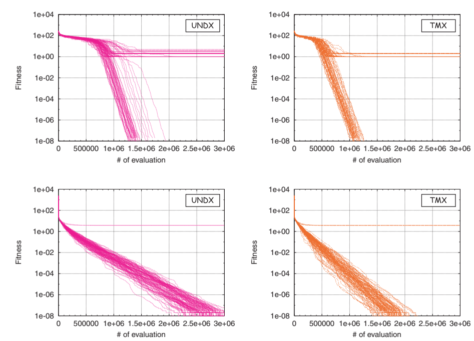

Figure 2: The transition curves of the best individuals on the Rotated-Rastrigin function (top) and Rosenbrock function (bottom).

2 Empirical Verification

We have compared TMX with Unimodal Normal Distribution Crossover (UNDX) [Ono 1997]. The transition curves of the best individuals are shown in Figure 2. On the Rotated-Rastrigin function (top), the required number of evaluation of the TMX is smaller and the curves are quite stable. On the Rosenbrock function (bottom), the convergence speeds of UNDX is very slow comparing with TMX.

References

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