Levy walk evolution for global optimization

Conference Paper · January 2008
DOI: 10.1145/1389095.1389200 · Source: DBLP

3 authors:

Onay Urfalioglu
25 PUBLICATIONS 98 CITATIONS
See Profile

A. Enis Cetin
Bilkent University
280 PUBLICATIONS 3,900 CITATIONS
See Profile

Ercan Engin Kuruoglu
Italian National Research Council
126 PUBLICATIONS 1,264 CITATIONS
See Profile

Some of the authors of this publication are also working on these related projects:

- Astrophysical image processing
- Image processing

All content following this page was uploaded by Onay Urfalioglu on 18 December 2013.
The user has requested enhancement of the downloaded file.
ABSTRACT
A novel evolutionary global optimization approach based on adaptive covariance estimation is proposed. The proposed method samples from a multivariate Levy Skew Alpha-Stable distribution with the estimated covariance matrix to realize a random walk and so to generate new solution candidates in the mutation step. The proposed method is compared to the popular Differential Evolution method, which is one of the best general evolutionary global optimizers available. Experimental results indicate that the proposed approach yields a general improvement in the required number of function evaluations to solve global optimization problems. Especially, as shown in experiments, the underlying heavy tailed alpha-stable distribution enables a considerably more effective global search in more complex problems.

1. INTRODUCTION
In many real world optimization problems the cost function is non-separable and the local optima count is very high. In addition, the local optima are distributed non-regularly. In many cases, given the currently discovered local optimum, the next best one is generally not within the close neighborhood [3].

In this paper, a global optimization method, the Levy Walk Evolution (LWE), is proposed. It is based on multivariate Levy Skew Alpha-Stable distribution (LSASD) with an adaptive covariance matrix and a crossover operator. The LSASD has the interesting property that, depending on the alpha parameter, its variance is infinite. Therefore, a random walk having an alpha-stable distribution involves long range sudden jumps. This property may lead to effective search patterns, especially in complex problems. In the literature, a clonal selection based evolutionary optimization approach using alpha-stable distributions can be found in [5], where it is reported that the proposed approach outperforms traditional Gaussian based mutation operators.

One of the popular evolutionary global optimization methods is Differential Evolution (DE) [4]. It is known for its adaptive mutation scheme, enabling relatively fast global convergence. In this paper, the proposed approach is compared to DE using several well known test problems from the literature.

2. LEVY WALK EVOLUTION
Similar to DE, the proposed method called Levy Walk Evolution (LWE) belongs to the class of population based evolutionary global search methods. In contrast to DE, the mutation step is realized by sampling from a Levy Skew Alpha-Stable distribution (LSASD). The LSASD has in general no analytically expressible probability density function. A 1-D LSASD has four parameters $\alpha, \beta, c, \mu$. The $\alpha$ parameter is the exponent and determines the shape of the distribution. For $\alpha = 2$ the distribution reduces to a Gaussian distribution, for $\alpha = 1$ and $\beta = 0$ it reduces to a Cauchy distribution and for $\alpha = 0.5$ and $\beta = 1$ it reduces to a Levy distribution. The $\beta$ parameter determines the skewness, where $\beta = 0$ leads to a symmetric distribution. The parameter $\mu$ determines the mean in the symmetric case. For $0 < \alpha < 2$, LSASD is a heavy tailed distribution with infinite variance.

In the mutation step of LWE, the weighted difference vector used in DE’s mutation step is replaced by a weighted sample from a multivariate LSASD. To enable an efficient global search, scale parameters are adaptively determined by calculating the covariance matrix, denoted by $\Sigma$, from the set of the positions of the particles. This covariance matrix is used in the multivariate LSASD. As a result, the mutation step becomes invariant under coordinate transforms. This invariance can also be found in DE through the difference vector utilization and also in the Evolution Strategy with Covariance Matrix Adaptation (CMA-ES) method [2, 1]. Each component shares the same parameter $\alpha$, which is provided by the user. The $\beta$ parameter and the mean $\mu$ is set...
In the following, the method of generating samples from a multivariate heavy tailed distribution based mutation with adaptive covariance matrix turns out to have the capability of escaping local optima even with a considerably less amount of particles. This is one of the reasons for the good performance of LWE on such complex problems.

As a general rule, decreasing the $\alpha$ parameter in LWE corresponds to heavier tailed distributions and this naturally enhances global search.

Another possible use case for alpha-stable distribution based evolutionary optimization methods could be found in robust optimization.

5. ACKNOWLEDGEMENTS

This work is supported in part by TÜBİTAK under the grant numbers EEEAG-105E065, 105E121 and AT FP6-507752 (MUSCLE-NoE).

6. REFERENCES


