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Effect of epistasis on the performance of genetic algorithms

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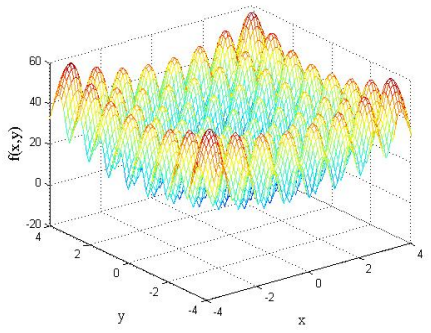
This study demonstrates that, in spite of what is generally assumed, GAs are not an efficient optimization tool

In non-epistatic problems, although a GA can possibly provide a correct solution, it is an inefficient and time-consuming algorithm.

Table 1 Functions with zero degree of epistasis

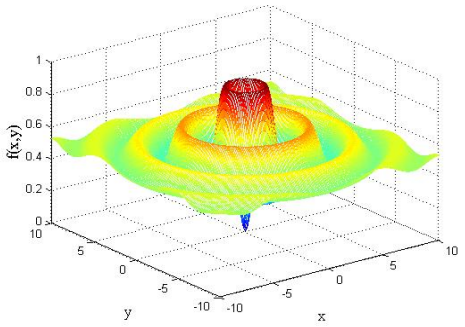
Function	Formula
F_1	$\sum_{n=1}^{N} x_n^2$
F_2	$\sum_{n=1}^{N} \lvert x_n \rvert - 10\cos\left(\sqrt{\lvert 10x_n \rvert}\right)$
F_3	$x\sin(4x) + 1.1y\sin(2y)$
F_4	$10N + \sum_{n=1}^{N}\left[x_n^2 - 10\cos(2\pi x_n)\right]$



The main operator of GA, mating (crossover), cannot function properly in epistatic optimization problems

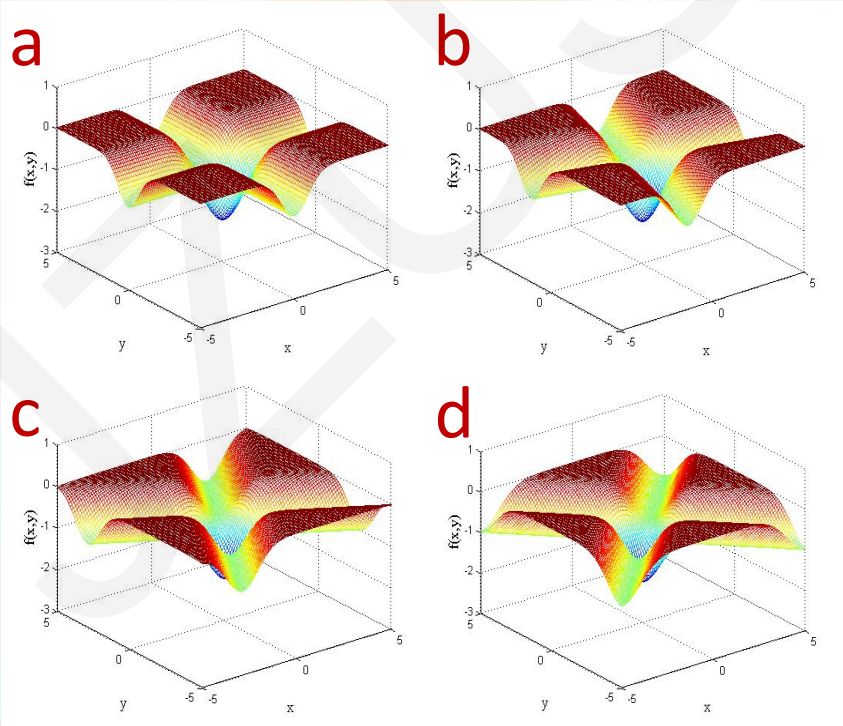
Table 2 Epistatic functions

Function	Formula
F_5	$\sum_{n=1}^{N}\left[100(x_{n+1}-x_n^2)^2+(1-x_n)^2\right]$
F_6	$0.5+\dfrac{\sin^2\left(\sqrt{x^2+y^2}\right)-0.5}{1+0.1(x^2+y^2)}$



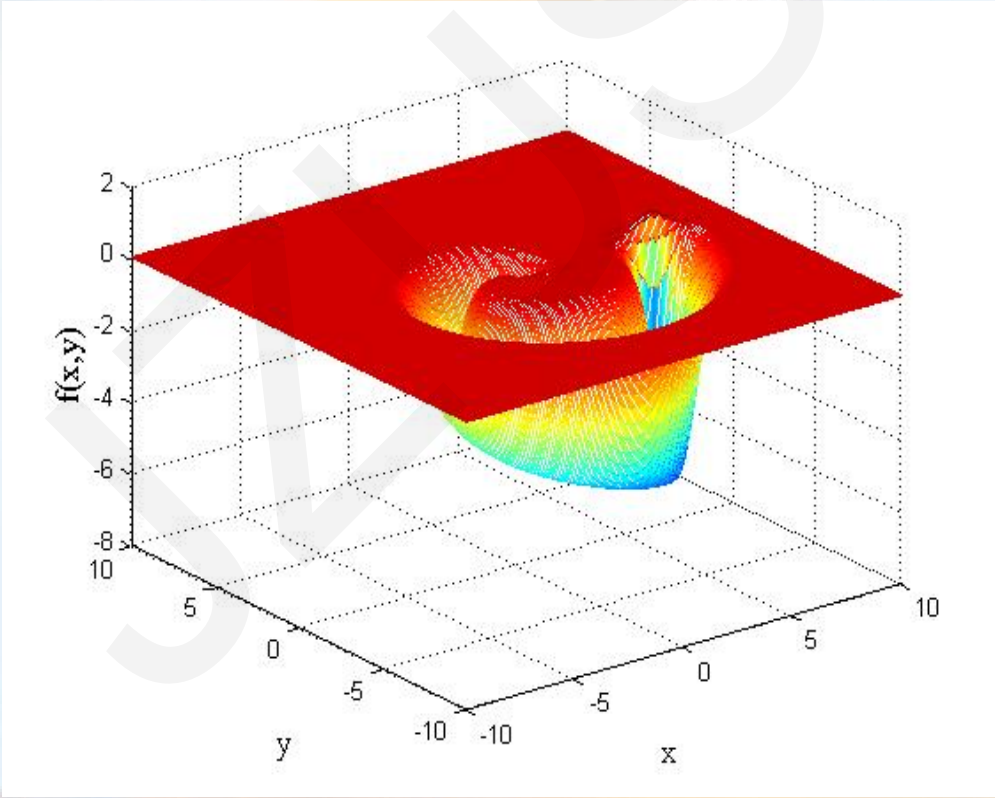
As proof, we used conventional test functions and introduced new ones and confirmed our claim with simulation results

$$F(x,y)=-(\mathrm{e}^{-(x\cos\theta-y\sin\theta)^2}+\mathrm{e}^{-(x\cos\theta+y\sin\theta)^2})$$



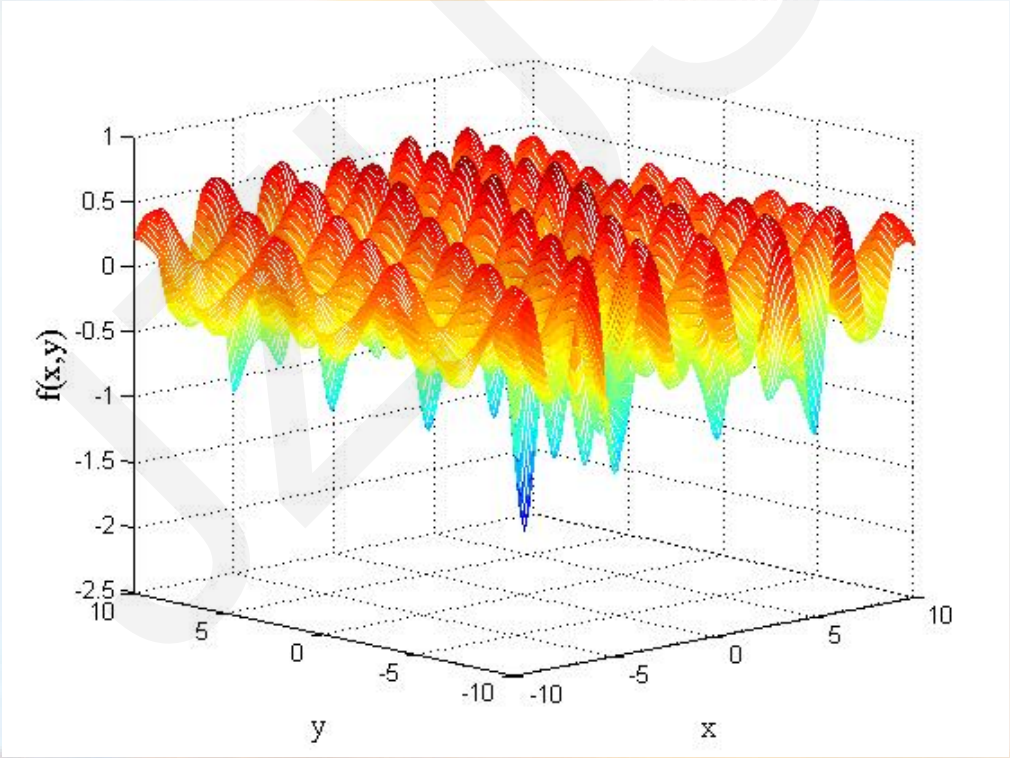
As proof, we used conventional test functions and introduced new ones and confirmed our claim with simulation results

$$F(x,y) = -r \times \mathrm{e}^{-(r-\theta)^2}$$



As proof, we used conventional test functions and introduced new ones and confirmed our claim with simulation results

$$F(x,y)=-\frac{\cos(ax+by)}{[(ax+by)^2]^m+k}-\frac{\cos(cx+dy)}{[(cx+dy)^2]^m+k}$$



Conclusions

In this work, the genetic algorithm technique has been challenged and criticized. We claim that, in spite of the generally positive assumption, a GA is not an efficient and useful optimization algorithm. It was shown that if the cost function is non-epistatic, the problem can be solved using GAs. However, it would be more efficient to use simple algorithms instead of GAs, since the N-dimensional function can be divided into N one-dimensional functions. Further, in most epistatic cost functions, GAs cannot find the correct solution. In addition to some commonly used benchmarks, our claim was evaluated and confirmed by three new test functions which were designed in this study.