Optimization with Differential Evolution (DE) and Evolution Strategies (ES)

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1 Introduction

In this homework, both Differential Evolution and Evolution Strategies are designed to optimize the following objective functions with two cases of variables are 2 and 10.

Objective functions:

- Ackley function
- Griewank function
- Rastrigin function
- Rosenbrock function
- Sphere function

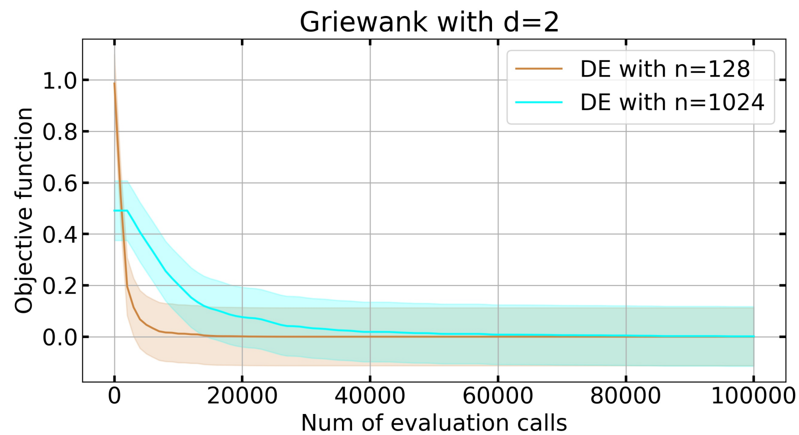
During the experiment, the population sizes will be changed to 32, 64, 128, 256, 512, 1024 respectively for each of the above functions. And for each change in population size, we will run experiments on 10 random seeds (from 19521281 to 19521290) and then save the best population or the best offspring along with the optimal value of the objective function. Finally, the objective function value of will be taken to calculate the corresponding mean and standard deviation.

2 Differential Evolution

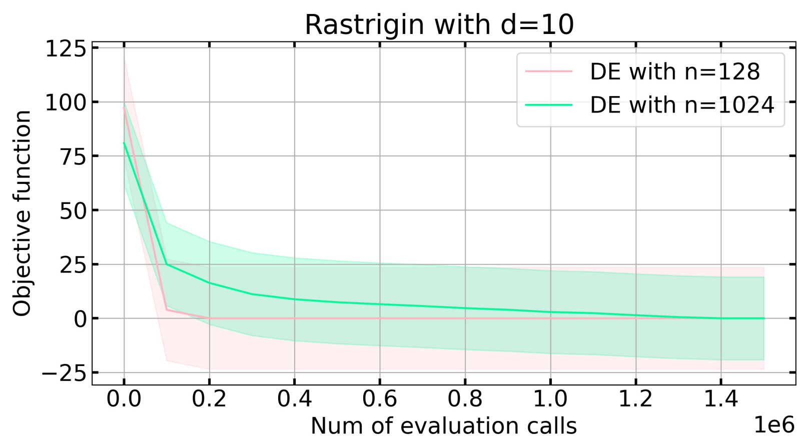
Differential Evolution (DE) is a modern evolutionary algorithm for solving global optimization problems in a real domain. The algorithm adjusts the range and direction of mutations based on the differences between individuals in the current population. The search for optimized values is performed randomly by applying mutation, crossover, and selection to make the population become the better solutions in the search space. For each individual in the population, selecting an individual and then three other individuals will be randomly selected from the unselected individuals.

In the process of running the model with both cases, we can see that DE takes a long time to find the optimal result (especially the Griewank function with 2 variables and the Rastrigin function with 2 variables). The main reason is in each generation, will generate and calculate the number of mutation vectors corresponding to the number of individuals in that generation; the latter is calculated based on the result of the former

Griewank function:



Rastrigin function:

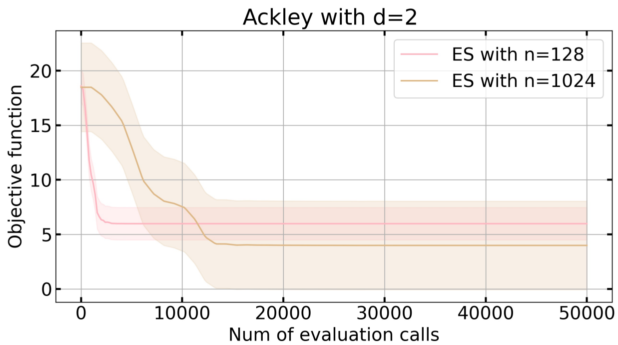


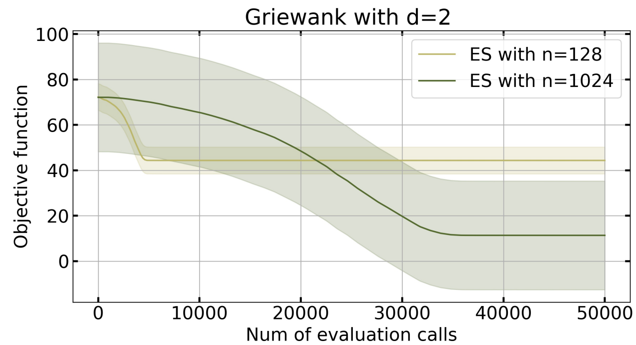
3 Evolution Strategies

Evolutionary strategy (ES) is a type of black-box optimization algorithm, born in the family of Evolutionary Algorithms (EA), and its optimization goals are vectors of real numbers. Evolutionary strategy is inspired by natural problem-dependent representations. So the process of evolution or in other words the implementation of this algorithm will be based on the idea of gradual selection or mutation and the population grows better adapted to the environment. Not only that, but the evolutionary strategy works well in cases where we don't know the exact analytic form of an objective function or cannot compute the gradations directly.

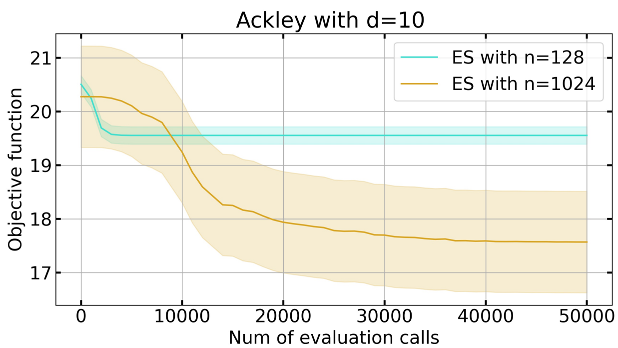
Evolutionary strategy is designed to be very diverse, but in this case we implement 1 plus a lambda, which means that after each process of creating offspring, we only take the best individual as a population and continue to mutate into other offsprings. Although the algorithm takes little time to execute, it does not seem to work well on objective functions with many local optima by a population of μ parents and recombination λ as an addition operator.

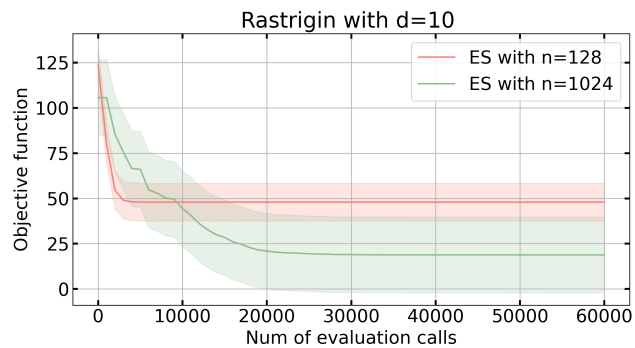
With d = 2





With d = 10





4 Conclusion

The population of DE through loops is always a set of individuals, so the range is wide and covers a lot of area, so most of the time is spent getting out of the local optima and moving towards the global extreme much more easily.

When it comes to ES, this algorithm scales well to higher dimensional problems or the increase in population. In addition, using ES for dealing with evaluation functions that do not yield reasonable results in a given period of time or give a good approximate solution is the best opt.