OPTIMUS: a multidimensional global optimization package

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Summary

This paper presents a programming tool written in ANSI C++, which researchers can use to formulate the problem to be solved and then make use of the local and global optimization methods provided by this tool to efficiently solve such problems. The main features of the suggested software are: a) Coding of the objective problem in a high level language such as ANSI C++ b) Incorporation of many global optimization techniques to tackle the objective problem c)Parameterization of global optimization methods using user-defined parameters d) Usage of a GUI application to control the optimization strategy.

Keywords: Global optimization; stochastic methods; Genetic algorithms; Software;

Software

The suggested software is entirely coded in ANSI C++, using the freely available QT programming library, which can be downloaded from https://qt.io. The researcher should code the objective function and a number of other mandatory functions in the C++ programming language. Also, the researcher should provide the dimension of the objective function as well as the bound of the function. Subsequently, the user can select a global optimization method to apply to the problem from a wide range of available methods.

Implemented global optimization methods

In the proposed software, each implemented global optimization method has a set of parameters that can determine the overall optimization path and the effectiveness of the method. Some of the global optimization methods are as follows:

METHOD	DESCRIPTION

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Differential Evolution	has been widely used in many areas.
Parallel Differential Evolution	divides the work into a number of available parallel computing units(V. Charilogis et al., 2023).
Double precision genetic algorithm	is included in the software and it is denoted as Genetic(I.G. Tsoulos et al., 2008).
Improved Particle Swarm Optimization	suggested by Charilogis and Tsoulos(V. Charilogis et al., 2022).
Multistart	initiates local searches from different initial points is also implemented in the software.
NeuralMinimizer	incorporates Radial Basis Functions (RBF) denoted by the name NeuralMinimizer(I.G. Tsoulos et al., 2023).
Parallel Particle Swarm optimizer	proposed in to develop a parallel PSO variant. The method is denoted as ParallelPso in the Optimus package(V. Charilogis et al., 2023).
Simulated annealing optimizer	included in the software under the name Simman.
The optimal foraging algorithm (OFA)	motivated by animal behavioral ecology included the software named Ofa (Kyrou, G. et al., 2024).
Bio-inspired metaheuristic algorithm Giant Armadillo Optimization (GAO)	mimics the natural behavior of the giant armadillo included in the software named armadillo1(Kyrou G. et al., 2024).
The Gray Wolf Optimizer (GWO)	mimics hunting mechanism of gray wolves in nature included in the software named Gwo.

Implemented local optimization methods

The parameter used to determine the used local optimization procedure is the –-opt_localsearch parameter. The implemented local optimization methods are the following:

METHOD	DESCRIPTION
The bfgs method	The Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm was implemented using a variant of Powell.

METHOD	DESCRIPTION
The lbfgs method	The limited memory BFGS method is implemented as an approximation of the BFGS method using a limited amount of computer memory
The Gradient descent method	This method is denoted as gradient in the software and implements the Gradient Descent local optimization procedure. T (I.G. Tsoulos et al., 2008) etc.
The Nelder Mead method	The Nelder Mead simplex procedure for local optimization is also included in the software and it is denoted as nelderMead.
The adam method	The adam local optimizer

Implementing a user - defined optimization method

The software can be extended by implementing optimization techniques by the user himself. For this purpose, there is the optimization method named UserMethod and the user can implement the provided functions according to the requirements of the method.

Method addParam()	DESCRIPTION
init()	This function is called every time the optimization method starts
step()	This function implements the actual step of the optimization method.
terminated()	This function is used as the termination step of the optimization method.
done()	This function will be called when the optimization method terminates.
~UserMethod()	This is the destructor of the optimization method.

A flowchart of any used optimization method is outlined in Figure 1

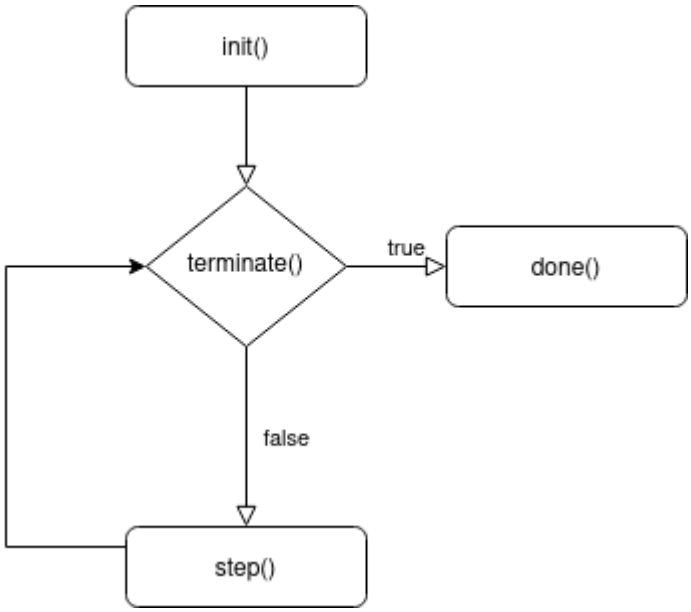

Figure 1. The flowchart of the execution steps of the optimization methods.

Conclusions

In this work, an environment for executing global optimization problems was presented. In this environment, the user can code the objective problem using some predefined functions and then has the possibility to choose one among several global optimization methods to solve the mentioned problem. In addition, it is given the possibility to choose to use some local optimization method to enhance the reliability of the produced results. This programming environment is freely available and easy to extend to accommodate more global optimization techniques.

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