

Advanced Global Optimization Methods and its Uses

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Abstract

In the (possible or known) presence of many local optima, the goal of global optimization is to identify the model's (potentially nonlinear) globally optimal solution. Formally, global optimization looks for one or more global solutions to an optimization model with constraints. Nonlinear models are frequently used in a wide range of fields, including scientific modelling, advanced engineering design, biotechnology, data analysis, environmental management, financial planning, process control, and risk management. They frequently need a global search strategy to find a solution.

Keywords: Biotechnology • Data analysis • Financial planning • Global optimization

Introduction

Some examples of applications include designing acoustics equipment, planning cancer therapies, modelling chemical processes, data analysis, classification, and visualisation, economic and financial forecasting, managing environmental risks, designing industrial products, designing laser equipment, optimising numerical mathematics, and packing. EAGO, an extendable open-source deterministic global optimizer written entirely in the Julia programming language. EAGO was created to accommodate user-defined functions with greater levels of complexity (such as those implicitly provided by algorithms) in optimization models [1]. EAGO incorporates a ground-breaking McCormick arithmetic implementation in an Evaluator structure, enabling the creation of convex/concave relaxations through the use of source code transformation, multiple dispatch, and context-specific strategies. Tools are provided to conduct symbolic transformations and parse user-defined functions into a directed acyclic graph representation, substantially accelerating solution times. The most comprehensive library of transcendental functions, a wide range of local optimizers that it is compatible with, and simple access through the JuMP modelling language are all features of EAGO [2].

The evolution of algorithms has been influenced by the increase in processing capacity over the past few decades. Through the use of parallel computing, high-performance computing clusters, and multi-core desktop computers, a significant amount of computational capacity has become accessible to academics all around the world. These research areas have benefited from this: First, the creation of more sophisticated, widely applicable, and nature-inspired heuristics, often known as metaheuristics. Second, it enabled substantial advancement in the area of precise, data-driven approximation models, also known as surrogate models, and their incorporation in an optimization procedure. Thirdly, there will soon be methods known as "hyperheuristics" that mix many optimization algorithms and aim to automatically assemble and configure the best optimization technique [3].

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Literature Review

These strong features make EAGO a flexible research platform that enables the easy creation of novel meta-solvers, incorporation and use of new relaxations, and extension to advanced problem formulations encountered in engineering and operations research. Together with Julia's minimal syntax and competitive speed (e.g. multilevel problems, user-defined functions). On a wide range of cases, the unique software's applicability and flexibility are shown. Finally, a benchmarking test set shows that EAGO performs on par with modern commercial optimizers [4].

In the (possible or known) presence of many local optima, the goal of global optimization is to identify the model's (potentially nonlinear) globally optimal solution. Formally, global optimization looks for one or more global solutions to an optimization model with constraints. Nonlinear models are frequently used in a wide range of fields, including scientific modelling, advanced engineering design, biotechnology, data analysis, environmental management, financial planning, process control, and risk management. They frequently need a global search strategy to find a solution [5].

Generally speaking, discrete or continuous search domains were the focus of development for the majority of GO algorithms. However, with only a few minor adjustments, many algorithms and their underlying search principles can be effective for other problem areas. For instance, evolution strategies (ES) originated in the discrete problem area and are now prominent in continuous optimization. The transition of the ES from discrete to continuous choice variables is described by Beyer and Schwefel. In light of this, the essay focuses on showing method variants for the continuous domain even though they originated in or perform best in the discrete domain [6].

Discussion

Some examples of applications include designing acoustics equipment, planning cancer therapies, modelling chemical processes, data analysis, classification, and visualisation, economic and financial forecasting, managing environmental risks, designing industrial products, designing laser equipment, optimising numerical mathematics, and packing.

It is necessary to do expensive computations, such as simulations or even real-world experiments, which are sometimes referred to as "black boxes," in order to solve optimization problems of this type. The various costs of function evaluations provide a basic problem in such systems. Whether we are querying the simulator, probing an actual physical system, or building a new complicated data model, these operations require a substantial amount of resources to complete. Therefore, GO techniques for these situations must meet a specific set of criteria. Without any additional knowledge of the problem's structure, they must only use black-box style probes. Additionally, they must identify the optimal improvement within a constrained set of function evaluations.

Additionally, we concentrated on algorithms for objective functions without specific traits like multi-objective, limited, noisy, or dynamic in this classification. Any algorithm must overcome these function properties, which present additional hurdles, by improving the available search schemes with specialised operators or even entirely dedicated algorithms. In our general algorithm scheme, we evaluated the former as part of the objective function evaluation and provided references to a few overviews. A detailed discussion of specialised algorithms, such as those for multi-objective search, is omitted. However, if their search strategies are connected to the algorithms defined in our taxonomy, then they can be accommodated in the given taxonomy. We described the unique applicability of algorithms and search operators to certain domains or problem features, as needed [7].

Conclusion

It combines a descent method and an extended random search method. The primary search method is random search. This search technique is improved by a newly created distribution-based area control that makes use of local minima that have already been found. The strategy is similar to deterministic optimization's traditional step size control. To find local minima, the descent method is integrated as a local search technique. This paper introduces CGRS, a unique implementation of this methodology. The conjugate gradient method is used as the descent method in CGRS. The proof of global convergence in probability for CGRS is given and extended to other descent methods used in the hybrid optimization approach.

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Conflict of Interest

There are no conflicts of interest by author.

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