**Method Article – Title Page**

|  |  |
| --- | --- |
| **Title** | ***OPTIMUS: a mitldimension global optimization package*** |
| **Authors** | *Vasileios Charilogis, Ioannis G. Tsoulos(\*)* |
| **Affiliations** | *Department of Informatics and Telecommunications, University of Ioannina, Greece* |
| **Corresponding Author’s email address** | *itsoulos@uoi.gr* |
| **Keywords** | * *Global optimization* * *Stochastic methods* * *Termination rules.* |
| **Direct Submission or Co-Submission** | Direct Submission |

**ABSTRACT**

There is a great need to discover the global optimum of multimodal functions that arises from many scientifical and practical problems. A base method used to solve this problem is the Multistart method. The proposed method extends the traditional method by adding two major features: the first one is a rejection mechanism to prevent the method from spending time in unnecessary function evaluations and the second is a stopping rule aimed to terminate the method when the global minimum has been located with some certainty. The proposed method has been evaluated on a series of global optimization functions from the relevant literature and it is compared against some other optimization methods and the experimental results are presented.

**GRAPHICAL ABSTRACT**

**SPECIFICATIONS TABLE**

|  |  |
| --- | --- |
| **Subject Area** | Computer Science |
| **More specific subject area** | *Global Optimization* |
| **Method name** | *NewMultistart* |
| **Name and reference of original method** |  |
| **Resource availability** | *https://github.com/itsoulos/OPTIMUS/* |

**\*Method details** A novel multistart based method is described and tested in the manuscript for global optimization problems. The method incorporate an asymptotic stopping rule to prevent the method from executing unnecessary local searches. This stopping rule terminates the algorithm, when under some certainty the global optimum has been located. Also, the proposed method utilizes an efficient discarding procedure which rejects points from being start points for the local search procedure if are too close to some other located local minima. This discarding procedure gradually creates a map of the regions of attraction for the underlying objective problem. The method was applied also in constrained optimization problems. As an example of the comparison results consider the following table, where the method is compared some other well – established methods in the area of global optimization. The testing is performed on some benchmark functions. The column CRS stands for the Controlled Random Search procedure, the column SA stands for the Simulated Annealing method, the column PSO for the Particle Swarm Optimization method and finally the column PROPOSED for the proposed method.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PROBLEM | CRS | SA | PSO | PROPOSED |
| BF1 | 2218 | 3845 | **2494** | 2833 |
| BF2 | 2207 | 3340 | 2641 | **2629** |
| BRANIN | 1744 | 4816 | **1636** | 1753 |
| CM4 | 4746 | 9652 | 2988 | **2293** |
| CAMEL | 1882 | 4820 | **1639** | 1732 |
| DIFFPOWER10 | 78634 | 25918 | 15500(0.87) | **19572** |
| EASOM | 588 | 4807 | 866 | **199** |
| EXP8 | 13239 | 19233 | 3084 | **2830** |
| EXP32 | 93520 | 76842 | 5055 | **3265** |
| GKLS250 | 1633 | 4120 | **1459** | 2415 |
| GKLS350 | 3329 | 7229 | 2259(0.97) | **243** |
| GRIEWANK2 | 2111 | 3830 | 2595(0.83) | **1786** |
| GRIEWANK10 | 32037 | 24118 | 8378(0.25) | **7184** |
| HANSEN | 3348 | 3323 | 4284 | **1510** |
| HARTMAN3 | 2898 | 7227 | **2448** | 11463 |
| HARTMAN6 | 9276 | 14440 | 4645 | **3740** |
| POTENTIAL5 | 95027 | 36084 | **20100** | 49601 |
| POTENTIAL10 | 193066 | 172166 | 19610(0.13) | 91094 |
| POTENTIAL20 | 189591(0.53) | 244314 | 18466(0.03) | 170524(0.97) |
| RASTRIGIN | 1906 | 3343 | 2258 | **675** |
| SHEKEL5 | 6345 | 9635 | 4791 | **3465** |
| SHEKEL7 | 6528 | 9334 | 5722 | **2976** |
| SHEKEL10 | 6477 | 9998 | 5354 | **3566** |
| SINU8 | 16950 | 19241 | 5398 | **549** |
| SINU32 | 100887 | 13858 | 6887 | **1296** |
| TEST2n4 | 6754 | 9631 | 5219 | **2890** |
| TEST2n5 | 12717 | 12036 | 7672 | **3262** |
| TEST2n6 | 12822 | 14438 | 8039 | **3451** |
| TEST2n7 | 18620 | 16840 | 8220 | **4002** |
| TEST30n3 | 2768 | 9616 | **2456** | 10818 |
| TEST30n4 | **3894** | 10617 | 4528 | 13320 |

**Acknowledgements:**The experiments of this research work was performed at the high performance computing system established at Knowledge and Intelligent Computing Lab-oratory, Dept of Informatics and Telecommunications, University of Ioannina, acquired with the project "Educational Laboratory equipment of TEI of Epirus" with MIS 5007094 funded by the Operational Programme "Epirus" 2014-2020, by ERDF and national finds.

**Declaration of interests:  *There are no conflicts of interest***

x The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

**\*References:**

1. References M.M. Ali, C. Storey, Topographical multilevel single linkage, J. Global Optimization 5, pp. 349–358,1994
2. I. G. Tsoulos and I. E. Lagaris, MinFinder: Locating all the local minima of a function, Computer Physics Communications 174, pp. 166-179, 2006.
3. I.E. Lagaris and I.G. Tsoulos, Stopping Rules for Box-Constrained Stochastic Global Optimization, Applied Mathematics and Computation 197, pp. 622-632, 2008.