

Package ‘EmiR’

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Type Package

Title Evolutionary Minimizer for R

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Description A C++ implementation of the following evolutionary algorithms: Bat Algorithm (Yang, 2010 <doi:10.1007/978-3-642-12538-6_6>), Cuckoo Search (Yang, 2009 <doi:10.1109/nabic.2009.5393690>), Genetic Algorithms (Holland, 1992, ISBN:978-0262581110), Gravitational Search Algorithm (Rashedi et al., 2009 <doi:10.1016/j.ins.2009.03.004>), Grey Wolf Optimization (Mirjalili et al., 2014 <doi:10.1016/j.advengsoft.2013.12.007>), Harmony Search (Geem et al., 2001 <doi:10.1177/003754970107600201>), Improved Harmony Search (Mahdavi et al., 2007 <doi:10.1016/j.amc.2006.11.033>), Moth-flame Optimization (Mirjalili, 2015 <doi:10.1016/j.knosys.2015.07.006>), Particle Swarm Optimization (Kennedy et al., 2001 ISBN:1558605959), Simulated Annealing (Kirkpatrick et al., 1983 <doi:10.1126/science.220.4598.671>), Whale Optimization Algorithm (Mirjalili and Lewis, 2016 <doi:10.1016/j.advengsoft.2016.01.008>). 'EmiR' can be used not only for unconstrained optimization problems, but also in presence of inequality constrains, and variables restricted to be integers.

License GPL-3

Encoding UTF-8

LazyData true

Depends R (>= 3.5.0)

Imports Rcpp (>= 1.0.5), methods, Rdpack, tictoc, ggplot2, tibble, tidyr, dplyr, gganimate, mathjaxr, data.table, plot3D, graphics

LinkingTo Rcpp, RcppProgress

RoxygenNote 7.1.2

Roxygen list(markdown = TRUE)

RdMacros Rdpack, mathjaxr

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Suggests xml2

R topics documented:

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ackley_func

*Ackley Function***Description**

Implementation of n-dimensional Ackley function, with $a = 20$, $b = 0.2$ and $c = 2\pi$ (see definition below).

Usage

```
ackley_func(x)
```

Arguments

x numeric or complex vector.

Details

On an n-dimensional domain it is defined by

$$f(\vec{x}) = -a \exp\left(-b \sqrt{\frac{1}{n} \sum_{i=1}^n x_i^2}\right) - \exp\left(\frac{1}{n} \sum_{i=1}^n \cos(cx_i)\right) + a + \exp(1),$$

and is usually evaluated on $x_i \in [-32.768, 32.768]$, for all $i = 1, \dots, n$. The function has one global minimum at $f(\vec{x}) = 0$ for $x_i = 0$ for all $i = 1, \dots, n$.

Value

The value of the function.

References

Ackley DH (1987). *A Connectionist Machine for Genetic Hillclimbing*. Springer US. doi:10.1007/9781461319979.

animate_population *Animation of population motion*

Description

Create an animation of the population motion for the minimization of 1D and 2D functions. The animation can be produced only if save_pop_history is TRUE in the options of the minimizer (see [MinimizerOpts](#)).

Usage

```
animate_population(minimizer_result, n_points = 100)
```

Arguments

minimizer_result

an object of class OptimizationResults (see [OptimizationResults](#)).

n_points

number of points per dimension used to draw the objective function. Default is 100.

bohachevsky_func *Bohachevsky Function*

Description

Implementation of 2-dimensional Bohachevsky function.

Usage

bohachevsky_func(x)

Arguments

x numeric or complex vector.

Details

On an 2-dimensional domain it is defined by

$$f(\vec{x}) = x_1^2 + 2x_2^2 - 0.3 \cos(3\pi x_1) - 0.4 \cos(4\pi x_2) + 0.7$$

and is usually evaluated on $x_i \in [-100, 100]$, for all $i = 1, 2$. The function has one global minimum at $f(\vec{x}) = 0$ for $\vec{x} = [0, 0]$.

Value

The value of the function.

References

Bohachevsky IO, Johnson ME, Stein ML (1986). "Generalized simulated annealing for function optimization." *Technometrics*, **28**(3), 209–217.

colville_func *Colville Function*

Description

Implementation of 4-dimensional Colville function.

Usage

colville_func(x)

Arguments

x numeric or complex vector.

Details

On an 4-dimensional domain it is defined by

$$f(\vec{x}) = 100(x_1^2 - x_2)^2 + (x_1 - 1)^2 + (x_3 - 1)^2 + 90(x_3^2 - x_4)^2 + 10.1((x_2 - 1)^2 + (x_4 - 1)^2) + 19.8(x_2 - 1)(x_4 - 1),$$

and is usually evaluated on $x_i \in [-10, 10]$, for all $i = 1, \dots, 4$. The function has one global minimum at $f(\vec{x}) = 0$ for $\vec{x} = [1, 1, 1, 1]$.

Value

The value of the function.

References

Grippo L, Lampariello F, Lucidi S (1989). "A truncated Newton method with nonmonotone line search for unconstrained optimization." *Journal of Optimization Theory and Applications*, **60**(3), 401–419. doi:10.1007/bf00940345.

config_abc

Configuration object for the Artificial Bee Colony Algorithm

Description

Create a configuration object for the Artificial Bee Colony Algorithm (ABC). At minimum the number of iterations (parameter `iterations`) and the number of bees (parameter `population_size`) have to be provided.

Usage

```
config_abc(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  employed_frac = 0.5,
  n_scout = 1
)
```

Arguments

<code>iterations</code>	maximum number of iterations.
<code>population_size</code>	number of bees.
<code>iterations_same_cost</code>	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If <code>NULL</code> the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is <code>NULL</code> .
<code>absolute_tol</code>	absolute tolerance when comparing best costs from consecutive iterations. If <code>NULL</code> the machine epsilon is used. Default is <code>NULL</code> .
<code>employed_frac</code>	fraction employed bees. Default is <code>0.5</code> .
<code>n_scout</code>	number of scout bees. Default is <code>1</code> .

Value

config_abc returns an object of class ABCConfig.

References

Karaboga D, Basturk B (2007). “A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm.” *Journal of Global Optimization*, **39**(3), 459–471. doi:10.1007/s108980079149x.

Examples

```
conf <- config_abc(iterations = 100, population_size = 50, iterations_same_cost = NULL,
  absolute_tol = NULL, employed_frac = 0.5, n_scout = 1)
```

config_algo

Configuration object for algorithms

Description

Create a configuration object for one of the algorithms available in EmiR. At minimum the id of the algorithm (parameter `algorithm_id`), the number of iterations (parameter `iterations`) and the number of individuals in the population (parameter `population_size`) have to be provided.

Usage

```
config_algo(
  algorithm_id,
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  ...
)
```

Arguments

<code>algorithm_id</code>	id of the algorithm to be used. See list_of_algorithms for the list of the available algorithms.
<code>iterations</code>	maximum number of iterations.
<code>population_size</code>	number of individuals in the population.
<code>iterations_same_cost</code>	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is NULL.
<code>absolute_tol</code>	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.
<code>...</code>	algorithm specific parameters (see specific configuration functions for more details).

Value

config_algo returns a configuration object specific for the specified algorithm.

Examples

```
conf <- config_algo(algorithm_id = "PS", population_size = 200, iterations = 10000)
```

 config_bat

Configuration object for the Bat Algorithm

Description

Create a configuration object for the Bat Algorithm (BAT). At minimum the number of iterations (parameter iterations) and the number of bats (parameter population_size) have to be provided.

Usage

```
config_bat(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  initial_loudness = 1.5,
  alpha = 0.9,
  initial_pulse_rate = 0.5,
  gamma = 0.9,
  freq_min = 0,
  freq_max = 2
)
```

Arguments

iterations	maximum number of iterations.
population_size	number of bats.
iterations_same_cost	maximum number of consecutive iterations with the <i>same</i> (see the parameter absolute_tol) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter iterations. Default is NULL.
absolute_tol	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.
initial_loudness	initial loudness of emitted pulses. Typical values are in the range [1, 2]. Default is 1.5.
alpha	parameter to control the linearly decreasing loudness with the iterations. It should be between 0 and 1. Default is 0.9.

initial_pulse_rate	initial rate at which pulses are emitted. It should be between 0 and 1. Default is 0.5.
gamma	parameter to control the exponentially decreasing pulse rate with the iterations. Default is 0.9.
freq_min	minimum frequency value of pulses. Default is 0.
freq_max	maximum frequency value of pulses. Default is 2.0.

Value

config_bat returns an object of class BATConfig.

References

Yang X (2010). “A new metaheuristic bat-inspired algorithm.” In *Nature inspired cooperative strategies for optimization (NICSO 2010)*, 65–74. Springer.

Examples

```
conf <- config_bat(iterations = 100, population_size = 50, iterations_same_cost = NULL,
absolute_tol = NULL, initial_loudness = 1.5, alpha = 0.9,
initial_pulse_rate = 0.5, gamma = 0.9,
freq_min = 0., freq_max = 2.)
```

config_cs

Configuration object for the Cuckoo Search Algorithm

Description

Create a configuration object for the Cuckoo Search Algorithm (CS). At minimum the number of iterations (parameter iterations) and the number of host nests (parameter population_size) have to be provided.

Usage

```
config_cs(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  discovery_rate = 0.25,
  step_size = 1
)
```


Arguments

iterations	maximum number of iterations.
population_size	number of host nests.
iterations_same_cost	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is NULL.
absolute_tol	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.
discovery_rate	probability for the egg laid by a cuckoo to be discovered by the host bird. It should be between 0 and 1. Default is 0.25.
step_size	step size of the Levy flight. Default is 1.0.

Value

`config_cs` returns an object of class `CSConfig`.

References

Yang X, Deb S (2009). "Cuckoo Search via Lévy flights." In *2009 World Congress on Nature & Biologically Inspired Computing (NaBIC)*. doi:[10.1109/nabic.2009.5393690](https://doi.org/10.1109/nabic.2009.5393690).

Examples

```
conf <- config_cs(iterations = 100, population_size = 50, iterations_same_cost = NULL,
absolute_tol = NULL, discovery_rate = 0.25, step_size = 1.0)
```

config_ga

Configuration object for the Genetic Algorithm

Description

Create a configuration object for the Genetic Algorithm (GA). At minimum the number of iterations (parameter `iterations`) and the number of chromosomes (parameter `population_size`) have to be provided.

Usage

```
config_ga(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  keep_fraction = 0.4,
  mutation_rate = 0.1
)
```

Arguments

iterations	maximum number of iterations.
population_size	number of chromosomes.
iterations_same_cost	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is NULL.
absolute_tol	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.
keep_fraction	fraction of the population that survives for the next step of mating. Default is 0.4.
mutation_rate	probability of mutation. Default is 0.1.

Value

`config_ga` returns an object of class `GAConfig`.

References

Holland JH (1992). *Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control and Artificial Intelligence*. MIT Press, Cambridge, MA, USA. ISBN 0262082136.

Examples

```
conf <- config_ga(iterations = 100, population_size = 50, iterations_same_cost = NULL,
absolute_tol = NULL, keep_fraction = 0.4, mutation_rate = 0.1)
```

config_gsa

Configuration object for the Gravitational Search Algorithm

Description

Create a configuration object for the Gravitational Search Algorithm (GSA). At minimum the number of iterations (parameter `iterations`) and the number of planets (parameter `population_size`) have to be provided.

Usage

```
config_gsa(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  grav = 1000,
  grav_evolution = 20
)
```

Arguments

iterations	maximum number of iterations.
population_size	number of planets.
iterations_same_cost	maximum number of consecutive iterations with the <i>same</i> (see the parameter <i>absolute_tol</i>) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter <i>iterations</i> . Default is NULL.
absolute_tol	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.
grav	gravitational constant, involved in the acceleration of planets. Default is 100.
grav_evolution	parameter to control the exponentially decreasing gravitational constant with the iterations. Default is 20.0.

Value

config_gsa returns an object of class GSAConfig.

References

Rashedi E, Nezamabadi-pour H, Saryazdi S (2009). “GSA: A Gravitational Search Algorithm.” *Information Sciences*, **179**(13), 2232–2248. doi:10.1016/j.ins.2009.03.004.

Examples

```
conf <- config_gsa(iterations = 100, population_size = 50, iterations_same_cost = NULL,
absolute_tol = NULL, grav = 1000, grav_evolution = 20.)
```

config_gwo

Configuration object for the Grey Wolf Optimizer Algorithm

Description

Create a configuration object for the Grey Wolf Optimizer Algorithm (GWO). At minimum the number of iterations (parameter *iterations*) and the number of wolves (parameter *population_size*) have to be provided.

Usage

```
config_gwo(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL
)
```

Arguments

iterations	maximum number of iterations.
population_size	number of wolves.
iterations_same_cost	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is NULL.
absolute_tol	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.

Value

`config_gwo` returns an object of class `GWOConfig`.

References

Mirjalili S, Mirjalili SM, Lewis A (2014). “Grey Wolf Optimizer.” *Advances in Engineering Software*, **69**, 46–61. doi:[10.1016/j.advengsoft.2013.12.007](https://doi.org/10.1016/j.advengsoft.2013.12.007).

Examples

```
conf <- config_gwo(iterations = 100, population_size = 50, iterations_same_cost = NULL,
absolute_tol = NULL)
```

config_hs

Configuration object for the Harmony Search Algorithm

Description

Create a configuration object for the Harmony Search Algorithm (HS). At minimum the number of iterations (parameter `iterations`) and the number of solutions in the harmony memory (parameter `population_size`) have to be provided.

Usage

```
config_hs(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  considering_rate = 0.5,
  adjusting_rate = 0.5,
  distance_bandwidth = 0.1
)
```

Arguments

iterations	maximum number of iterations.
population_size	number of solutions in the harmony memory.
iterations_same_cost	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is NULL.
absolute_tol	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.
considering_rate	probability for each component of a newly generated solution to be recalled from the harmony memory.
adjusting_rate	probability of the pitch adjustment in case of a component recalled from the harmony memory.
distance_bandwidth	amplitude of the random pitch adjustment.

Value

`config_hs` returns an object of class `HSConfig`.

References

Lee KS, Geem ZW (2004). "A new structural optimization method based on the harmony search algorithm." *Computers & Structures*, **82**(9-10), 781–798. doi:10.1016/j.compstruc.2004.01.002.

Examples

```
conf <- config_hs(iterations = 100, population_size = 50, iterations_same_cost = NULL,
absolute_tol = NULL, considering_rate = 0.5, adjusting_rate = 0.5,
distance_bandwidth = 0.1)
```

config_ihs

Configuration object for the Improved Harmony Search Algorithm

Description

Create a configuration object for the Improved Harmony Search Algorithm (IHS). At minimum the number of iterations (parameter `iterations`) and the number of solutions in the harmony memory (parameter `population_size`) have to be provided.

Usage

```

config_ihs(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  considering_rate = 0.5,
  min_adjusting_rate = 0.3,
  max_adjusting_rate = 0.99,
  min_distance_bandwidth = 1e-04,
  max_distance_bandwidth = 1
)

```

Arguments

`iterations` maximum number of iterations.

`population_size` number of solutions in the harmony memory.

`iterations_same_cost` maximum number of consecutive iterations with the *same* (see the parameter `absolute_tol`) best cost before ending the minimization. If `NULL` the minimization continues for the number of iterations specified by the parameter `iterations`. Default is `NULL`.

`absolute_tol` absolute tolerance when comparing best costs from consecutive iterations. If `NULL` the machine epsilon is used. Default is `NULL`.

`considering_rate` probability for each component of a newly generated solution to be recalled from the harmony memory.

`min_adjusting_rate` minimum value of the pitch adjustment probability.

`max_adjusting_rate` maximum value of the pitch adjustment probability.

`min_distance_bandwidth` minimum amplitude of the random pitch adjustment.

`max_distance_bandwidth` maximum amplitude of the random pitch adjustment.

Value

`config_ihs` returns an object of class `IHSConfig`.

References

Mahdavi M, Fesanghary M, Damangir E (2007). "An improved harmony search algorithm for solving optimization problems." *Applied Mathematics and Computation*, **188**(2), 1567–1579. doi:10.1016/j.amc.2006.11.033.

Examples

```

conf <- config_ihs(iterations = 100, population_size = 50, iterations_same_cost = NULL,
  absolute_tol = NULL, considering_rate = 0.5, min_adjusting_rate = 0.3,
  max_adjusting_rate = 0.99, min_distance_bandwidth = 0.0001, max_distance_bandwidth = 1)

```

`config_mfo`*Configuration object for the Moth-flame Optimization Algorithm*

Description

Create a configuration object for the Moth-flame Optimization Algorithm (MFO). At minimum the number of iterations (parameter `iterations`) and the number of moths (parameter `population_size`) have to be provided.

Usage

```
config_mfo(  
  iterations,  
  population_size,  
  iterations_same_cost = NULL,  
  absolute_tol = NULL  
)
```

Arguments

<code>iterations</code>	maximum number of iterations.
<code>population_size</code>	number of moths.
<code>iterations_same_cost</code>	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If <code>NULL</code> the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is <code>NULL</code> .
<code>absolute_tol</code>	absolute tolerance when comparing best costs from consecutive iterations. If <code>NULL</code> the machine epsilon is used. Default is <code>NULL</code> .

Value

`config_mfo` returns an object of class `MFOConfig`.

References

Mirjalili S (2015). “Moth-flame optimization algorithm: A novel nature-inspired heuristic paradigm.” *Knowledge-Based Systems*, **89**, 228–249. doi:[10.1016/j.knosys.2015.07.006](https://doi.org/10.1016/j.knosys.2015.07.006).

Examples

```
conf <- config_mfo(iterations = 100, population_size = 50, iterations_same_cost = NULL,  
absolute_tol = NULL)
```

config_ps

*Configuration object for the Particle Swarm Algorithm***Description**

Create a configuration object for the Particle Swarm Algorithm (PS). At minimum the number of iterations (parameter `iterations`) and the number of particles (parameter `population_size`) have to be provided.

Usage

```
config_ps(
    iterations,
    population_size,
    iterations_same_cost = NULL,
    absolute_tol = NULL,
    alpha_vel = 0.5,
    alpha_evolution = 1,
    cognitive = 2,
    social = 2,
    inertia = 0.9
)
```

Arguments

<code>iterations</code>	maximum number of iterations.
<code>population_size</code>	number of particles.
<code>iterations_same_cost</code>	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is NULL.
<code>absolute_tol</code>	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.
<code>alpha_vel</code>	maximum velocity of particles, defined as a fraction of the range on each parameter. Default is 0.5.
<code>alpha_evolution</code>	parameter to control the decreasing <code>alpha_vel</code> value with the iterations. Default is 1.0 (linear).
<code>cognitive</code>	parameter influencing the motion of the particle on the basis of distance between its current and best positions. Default is 2.0.
<code>social</code>	parameter influencing the motion of the particle on the basis of distance between its current position and the best position in the swarm. Default is 2.0.
<code>inertia</code>	parameter influencing the dependency of the velocity on its value at the previous iteration. Default 0.9.

Value

`config_ps` returns an object of class `PSConfig`.

References

Eberhart R, Kennedy J (1995). “A new optimizer using particle swarm theory.” In *MHS'95. Proceedings of the Sixth International Symposium on Micro Machine and Human Science*, 39–43. Ieee.

Examples

```
conf <- config_ps(iterations = 100, population_size = 50, iterations_same_cost = NULL,
  absolute_tol = NULL, alpha_vel = 0.5, alpha_evolution = 1.0, cognitive = 2.0,
  social = 2.0, inertia = 0.9)
```

config_sa

Configuration object for the Simulated Annealing Algorithm

Description

Create a configuration object for the Simulated Annealing algorithm (SA). At minimum the number of iterations (parameter `iterations`) and the number of particles (parameter `population_size`) have to be provided.

Usage

```
config_sa(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL,
  T0 = 50,
  Ns = 3,
  Nt = 3,
  c_step = 2,
  Rt = 0.85,
  Wmin = 0.25,
  Wmax = 1.25
)
```

Arguments

<code>iterations</code>	maximum number of iterations.
<code>population_size</code>	number of particles.
<code>iterations_same_cost</code>	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If <code>NULL</code> the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is <code>NULL</code> .
<code>absolute_tol</code>	absolute tolerance when comparing best costs from consecutive iterations. If <code>NULL</code> the machine epsilon is used. Default is <code>NULL</code> .
<code>T0</code>	initial temperature. Default is 50.
<code>Ns</code>	number of iterations before changing velocity. Default is 3.

Nt	number of iterations before changing the temperature. Default is 3.
c_step	parameter involved in the velocity update. Default is 2.
Rt	scaling factor for the temperature. Default is 0.85.
Wmin	parameter involved in the generation of the starting point. Default is 0.25.
Wmax	parameter involved in the generation of the starting point. Default is 1.25.

Value

config_sa returns an object of class SAConfig.

References

Kirkpatrick S, Gelatt CD, Vecchi MP (1983). "Optimization by Simulated Annealing." *Science*, **220**(4598), 671–680. doi:10.1126/science.220.4598.671.

Examples

```
conf <- config_sa(iterations = 100, population_size = 50, iterations_same_cost = NULL,
  absolute_tol = NULL, T0 = 50., Ns = 3., Nt = 3., c_step = 2., Rt = 0.85, Wmin = 0.25,
  Wmax = 1.25)
```

config_woa

Configuration object for the Whale Optimization Algorithm

Description

Create a configuration object for the Whale Optimization Algorithm (WOA). At minimum the number of iterations (parameter `iterations`) and the number of whales (parameter `population_size`) have to be provided.

Usage

```
config_woa(
  iterations,
  population_size,
  iterations_same_cost = NULL,
  absolute_tol = NULL
)
```

Arguments

<code>iterations</code>	maximum number of iterations.
<code>population_size</code>	number of whales.
<code>iterations_same_cost</code>	maximum number of consecutive iterations with the <i>same</i> (see the parameter <code>absolute_tol</code>) best cost before ending the minimization. If NULL the minimization continues for the number of iterations specified by the parameter <code>iterations</code> . Default is NULL.
<code>absolute_tol</code>	absolute tolerance when comparing best costs from consecutive iterations. If NULL the machine epsilon is used. Default is NULL.

Value

config_woa returns an object of class WOAConfig.

References

Mirjalili S, Lewis A (2016). "The Whale Optimization Algorithm." *Advances in Engineering Software*, **95**, 51-67. ISSN 0965-9978, doi:10.1016/j.advengsoft.2016.01.008, <https://www.sciencedirect.com/science/article/pii/S0965997816300163>.

Examples

```
conf <- config_woa(iterations = 100, population_size = 50, iterations_same_cost = NULL,
absolute_tol = NULL)
```

constrained_function *Constrained function for minimization*

Description

Create a constrained function for minimization.

Usage

```
constrained_function(func, ...)
```

Arguments

func	original objective function.
...	one or more constraints of class Constraint. See constraint .

Value

constrained_function returns an object of class ConstrainedFunction.

constraint *Constraint for minimization*

Description

Create a constraint function for constrained optimization. Only inequality constraints are supported.

Usage

```
constraint(func, inequality)
```

Arguments

func	function describing the constraint.
inequality	inequality type. Possible values: >, >=, <=, <.

Value

constraint returns an object of class Constraint.

Examples

```
g1 <- function(x) 0.0193*x[3] - (x[1]*0.0625)
c1 <- constraint(g1, "<=")
```

freudenstein_roth_func

Freudenstein Roth Function

Description

Implementation of 2-dimensional Freudenstein Roth function.

Usage

```
freudenstein_roth_func(x)
```

Arguments

x numeric or complex vector.

Details

On an 2-dimensional domain it is defined by

$$f(\vec{x}) = (x_1 - 13 + ((5 - x_2)x_2 - 2)x_2)^2 + (x_1 - 29 + ((x_2 + 1)x_2 - 14)x_2)^2$$

and is usually evaluated on $x_i \in [-10, 10]$, for all $i = 1, 2$. The function has one global minimum at $f(\vec{x}) = 0$ for $\vec{x} = [5, 4]$.

Value

The value of the function.

References

Rao S (2019). *Engineering optimization : theory and practice*. John Wiley and Sons, Ltd, Hoboken, NJ, USA. ISBN 978-1-119-45479-3.

G01InitPop

Data set for example G01

Description

This data set contains the initial positions for a population of size 20 to be used with the example G01.

get_population	<i>Get population positions</i>
----------------	---------------------------------

Description

Return a `data.frame` with the position of all individuals in the population at the specified iteration, from an object of class `OptimizationResults` produced with the option `save_pop_history` set to `TRUE` (see [MinimizerOpts](#)).

Usage

```
get_population(minimizer_result, iteration)
```

Arguments

`minimizer_result` an object of class `OptimizationResults` (see [OptimizationResults](#)).

`iteration` iteration number.

Value

An object of class `data.frame`.

griewank_func	<i>Griewank Function</i>
---------------	--------------------------

Description

Implementation of n-dimensional Griewank function.

Usage

```
griewank_func(x)
```

Arguments

`x` numeric or complex vector.

Details

On an n-dimensional domain it is defined by

$$f(\vec{x}) = 1 + \sum_{i=1}^n \frac{x_i^2}{4000} - \prod_{i=1}^n \cos\left(\frac{x_i}{\sqrt{i}}\right),$$

and is usually evaluated on $x_i \in [-600, 600]$, for all $i = 1, \dots, n$. The function has global minima at $f(\vec{x}) = 0$ for $x_i = 0$ for all $i = 1, \dots, n$.

Value

The value of the function.

References

Griewank AO (1981). “Generalized descent for global optimization.” *Journal of optimization theory and applications*, **34**(1), 11–39.

`list_of_algorithms` *Return the list of algorithms in EmiR*

Description

Return a `data.frame` with the ID, description and configuration function name of all the algorithms implemented in EmiR.

Usage

```
list_of_algorithms()
```

Value

An object of class `data.frame`.

`list_of_functions` *Return the list of pre-defined functions in EmiR*

Description

Return a `data.frame` with function name, full name, and minimum and maximum number of parameters accepted for all the pre-defined functions in EmiR.

Usage

```
list_of_functions()
```

Value

An object of class `data.frame`.

miele_cantrell_func	<i>Miele Cantrell Function</i>
---------------------	--------------------------------

Description

Implementation of 4-dimensional Miele Cantrell Function.

Usage

```
miele_cantrell_func(x)
```

Arguments

x numeric or complex vector.

Details

On an 4-dimensional domain it is defined by

$$f(\vec{x}) = (e^{-x_1} - x_2)^4 + 100(x_2 - x_3)^6 + (\tan(x_3 - x_4))^4 + x_1^8$$

and is usually evaluated on $x_i \in [-2, 2]$, for all $i = 1, \dots, 4$. The function has one global minimum at $f(\vec{x}) = 0$ for $\vec{x} = [0, 1, 1, 1]$.

Value

The value of the function.

References

Cragg EE, Levy AV (1969). “Study on a supermemory gradient method for the minimization of functions.” *Journal of Optimization Theory and Applications*, **4**(3), 191–205.

minimize	<i>Minimize an Objective Function</i>
----------	---------------------------------------

Description

Minimize (or maximize) an objective function, possibly subjected to inequality constraints, using any of the algorithms available in EmiR.

Usage

```
minimize(algorithm_id, obj_func, parameters, config, constraints = NULL, ...)
```

Arguments

algorithm_id	id of the algorithm to be used. See list_of_algorithms for the list of the available algorithms.
obj_func	objective function be minimized/maximized.
parameters	list of parameters composing the search space for the objective function. Parameters are requested to be objects of class Parameter (see parameter).
config	an object with the configuration parameters of the chosen algorithm. For each algorithm there is different function for the tuning of its configuration parameter, as reported in the following list: <ul style="list-style-type: none"> • config_abc – configuration function for the <i>Artificial Bee Colony Algorithm</i>. • config_bat – configuration function for the <i>Bat Algorithm</i>. • config_cs – configuration function for the <i>Cuckoo Search Algorithm</i>. • config_ga – configuration function for the <i>Genetic Algorithm</i>. • config_gsa – configuration function for the <i>Gravitational Search Algorithm</i>. • config_gwo – configuration function for the <i>Grey Wolf Optimizer Algorithm</i>. • config_hs – configuration function for the <i>Harmony Search Algorithm</i>. • config_ihs – configuration function for the <i>Improved Harmony Search Algorithm</i>. • config_mfo – configuration function for the <i>Moth-flame Optimization Algorithm</i>. • config_ps – configuration function for the <i>Particle Swarm Algorithm</i>. • config_sa – configuration function for the <i>Simulated Annealing algorithm</i>. • config_woa – configuration function for the <i>Whale Optimization Algorithm</i>.
constraints	list of constraints. Constraints are requested to be objects of class Constraint (see constraint).
...	additional options (see MinimizerOpts).

Value

minimize returns an object of class OptimizationResults (see [OptimizationResults](#)).

Examples

```
## Not run:
results <- minimize(algorithm_id = "BAT", obj_func = ob, config = conf,
  parameters = list(p1,p2, p3, p4), constraints = list(c1,c2,c3),
  save_pop_history = TRUE, constrained_method = "BARRIER",
  constr_init_pop = TRUE, oob_solutions = "RBC", seed = 1)

## End(Not run)
```


MinimizerOpts

*EmiR optimization options***Description**

A S4 class storing the options for the optimization algorithms in EmiR.

Slots

`maximize` if TRUE the objective function is maximized instead of being minimized. Default is FALSE.

`silent_mode` if TRUE no output to console is generated. Default is FALSE.

`save_pop_history` if TRUE the position of all individuals in the population at each iteration is stored. This is necessary for functions like `plot_population` and `animate_population` to work. Default is FALSE.

`constrained_method` method for constrained optimization. Possible values are:

- "PENALTY" - Penalty Method: the constrained problem is converted to an unconstrained one, by adding a *penalty function* to the objective function. The penalty function consists of a *penalty parameter* multiplied by a measure of violation of the constraints. The penalty parameter is multiplied by a scale factor (see `penalty_scale`) at every iteration;
- "BARRIER" - Barrier Method: the value of the objective function is set equal to an arbitrary large positive (or negative in case of maximization) number if any of the constraints is violated;
- "ACCREJ" - Acceptance-Rejection method: a solution violating any of the constraints is replaced by a randomly generated new one in the feasible region. Default is "PENALTY".

`penalty_scale` scale factor for the *penalty parameter* at each iteration. It should be greater than 1. Default is 10.

`start_penalty_param` initial value of the *penalty parameter*. It should be greater than 0. Default is 2.

`max_penalty_param` maximum value for the *penalty parameter*. It should be greater than 0. Default is 1.e+10.

`constr_init_pop` if TRUE the initial population is generated in the *feasible region* only. Default is TRUE.

`oob_solutions` strategy to treat out-of-bound solutions. Possible values are:

- "RBC" - Reflective Boundary Condition: the solution is placed back inside the search domain at a position which is distanced from the boundary as the out-of-bound excess. Depending on the optimization algorithm, the velocity of the corresponding individual of the population could be also inverted;
- "PBC" - Periodic Boundary Condition: the solution is placed back inside the search domain at a position which is distanced from the *opposite* boundary as the out-of-bound excess;
- "BAB" - Back At Boundary: the solution is placed back at the boundaries for the out-of-bound dimensions;
- "DIS" - Disregard the solution: the solution is replaced by a new one, which is randomly generated in the search space. Default is "DIS".

`seed` seed for the internal random number generator. Accepted values are strictly positive integers. If NULL a random seed at each execution is used. Default is NULL.

`initial_population` manually specify the position of the initial population. A $n \times d$ matrix has to be provided, where n is the population size and d is the number of parameters the objective function is minimized with respect to.

OptimizationResults *EmiR optimization results*

Description

A S4 class storing all relevant data from an optimization with EmiR.

Slots

`algorithm` the name of the algorithm.

`iterations` the number of iterations.

`population_size` the number of individuals in the population.

`obj_function` the minimized/maximized objective function.

`constraints` the constraints the objective function is subjected to.

`best_cost` the best value of the objective function found.

`best_parameters` the parameter values for which the best cost was obtained.

`parameter_range` the range on the parameters.

`pop_history` list containing the positions of all individuals in the population at each iteration. The list is filled only if `save_pop_history` is TRUE in the options of the minimizer (see [MinimizeROpts](#)).

`cost_history` the vector storing the best value of the objective function at each iteration.

`exec_time_sec` the execution time in seconds.

`is_maximization` if TRUE the objective function has been maximized instead of being minimized.

parameter *Parameter for minimization*

Description

Create a parameter the objective function is minimized with respect to.

Usage

```
parameter(name, min_val, max_val, integer = FALSE)
```

Arguments

`name` name of the parameter.

`min_val` minimum value the parameter is allowed to assume during minimization.

`max_val` maximum value the parameter is allowed to assume during minimization.

`integer` if TRUE the parameter is constrained to be integer. Default is FALSE.

Value

parameter returns an object of class Parameter.

Examples

```
p1 <- parameter("x1", 18, 32, integer = TRUE)
```

 parameters

Set of parameters for minimization

Description

Create the set of parameters the objective function is minimized with respect to. A $2 \times n$ matrix or a $3 \times n$ matrix, where the first row is for the lower limits, the second one is for the upper limits, and the (optional) third one is to specify if a parameter is constrained to be integer. In case the third row is not provided, all the parameters are treated as continuous. The name of each of the n parameters is automatically generated and it is of the form x_i , where $i = 1, \dots, n$.

Usage

```
parameters(values)
```

Arguments

values a $2 \times n$ matrix or a $3 \times n$ matrix.

Value

parameters returns a list of objects of class Parameter.

 plot_history

Plot minimization history

Description

Plot the minimization history as a function of the number of iterations.

Usage

```
plot_history(minimizer_result, ...)
```

Arguments

minimizer_result

an object of class OptimizationResults (see [OptimizationResults](#)).

...

additional arguments, such as graphical parameters (see [plot](#)).

plot_population	<i>Plot the population position</i>
-----------------	-------------------------------------

Description

Plot the position of all individuals in the population, at a given iteration, for 1D and 2D functions. The plot can be produced only if `save_pop_history` is `TRUE` in the options of the minimizer (see [MinimizerOpts](#)).

Usage

```
plot_population(minimizer_result, iteration, n_points = 100)
```

Arguments

minimizer_result	an object of class <code>OptimizationResults</code> (see OptimizationResults).
iteration	iteration at which the population is plotted.
n_points	number of points per dimension used to draw the objective function. Default is 100.

rastrigin_func	<i>Rastrigin Function</i>
----------------	---------------------------

Description

Implementation of n-dimensional Rastrigin function.

Usage

```
rastrigin_func(x)
```

Arguments

x	numeric or complex vector.
---	----------------------------

Details

On an n-dimensional domain it is defined by:

$$f(\vec{x}) = 20n + \sum_{i=1}^n (x_i^2 - 20 \cos(2\pi x_i)),$$

and is usually evaluated on $x_i \in [-5.12, 5.12]$, for all $i = 1, \dots, n$. The function has one global minimum at $f(\vec{x}) = 0$ for $x_i = 0$ for all $i = 1, \dots, n$.

Value

The value of the function.

References

Rastrigin LA (1974). “Systems of extremal control.” *Nauka*.

rosenbrock_func	<i>Rosenbrock Function</i>
-----------------	----------------------------

Description

Implementation of n-dimensional Rosenbrock function, with $n \geq 2$.

Usage

`rosenbrock_func(x)`

Arguments

`x` numeric or complex vector.

Details

On an n-dimensional domain it is defined by

$$f(\vec{x}) = \sum_{i=1}^{n-1} [100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2],$$

and is usually evaluated on $x_i \in [-5, 10]$, for all $i = 1, \dots, n$. The function has one global minimum at $f(\vec{x}) = 0$ for $x_i = 1$ for all $i = 1, \dots, n$.

Value

The value of the function.

References

Rosenbrock HH (1960). “An Automatic Method for Finding the Greatest or Least Value of a Function.” *The Computer Journal*, **3**(3), 175–184. doi:10.1093/comjnl/3.3.175.

schwefel_func *Schwefel Function*

Description

Implementation of n-dimensional Schwefel function.

Usage

schwefel_func(x)

Arguments

x numeric or complex vector.

Details

On an n-dimensional domain it is defined by

$$f(\vec{x}) = \sum_{i=1}^n \left[-x_i \sin(\sqrt{|x_i|}) \right],$$

and is usually evaluated on $x_i \in [-500, 500]$, for all $i = 1, \dots, n$. The function has one global minimum at $f(\vec{x}) = -418.9829n$ for $x_i = 420.9687$ for all $i = 1, \dots, n$.

Value

The value of the function.

References

Schwefel H (1981). *Numerical optimization of computer models*. John Wiley & Sons, Inc.

styblinski_tang_func *Styblinski-Tang Function*

Description

Implementation of n-dimensional Styblinski-Tang function.

Usage

styblinski_tang_func(x)

Arguments

x numeric or complex vector.

Details

On an n -dimensional domain it is defined by

$$f(\vec{x}) = \frac{1}{2} \sum_{i=1}^n (x_i^4 - 16x_i^2 + 5x_i),$$

and is usually evaluated on $x_i \in [-5, 5]$, for all $i = 1, \dots, n$. The function has one global minimum at $f(\vec{x}) = -39.16599n$ for $x_i = -2.903534$ for all $i = 1, \dots, n$.

Value

The value of the function.

References

Styblinski MA, Tang T (1990). "Experiments in nonconvex optimization: Stochastic approximation with function smoothing and simulated annealing." *Neural Networks*, **3**(4), 467–483. doi:10.1016/08936080(90)90029k.

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