Package 'emoa'

September 6, 2024

Title Evolutionary Multiobjective Optimization Algorithms

Description Collection of building blocks for the design and analysis of evolutionary multiobjective optimization algorithms.

License GPL-2

URL https://github.com/olafmersmann/emoa/

LazyData yes

Version 0.5-3

Suggests testthat

Encoding UTF-8

RoxygenNote 7.2.3

NeedsCompilation yes

Author Olaf Mersmann [aut, cre] (<https://orcid.org/0000-0002-7720-4939>)

Maintainer Olaf Mersmann <olafm@p-value.net>

Repository CRAN

Date/Publication 2024-09-06 15:30:02 UTC

Contents

`emoa-package` *The EMOA package*

Description

This package provides functions to construct evolutionary multiobjective optimization algorithms (EMOA). The long term goal is to also provide standard implementations of the most common EMOA in use today.

Details

Without the hard work of many researchers who have published their source code under a liberal license, this package would not have been possible. In alphabetical order they are

- Michael H. Buselli
- Wessel Dankers
- Carlos Fonseca
- Joshua Knowles
- Huang Ling
- Wudong Liu
- Manuel Lopez-Ibanez
- Luis Paquete
- Ponnuthurai Nagaratnam Suganthany
- Santosh Tiwar
- Qingfu Zhang
- Aimin Zhou
- Shizheng Zhaoy

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

cec2007 *CEC 2007 multiobjective optimization competition results*

Description

This data set contains the hypervolume and R2 indicator results of the 8 different algorithms that took part in the CEC 2007 multiobjective optimization benchmark.

Usage

```
data(cec2007)
```

Format

A data frame with 456 observations of the following 9 variables.

`algo` Abbreviated name of algorithm

`fun` Name of benchmark function

`d` Dimension of objective space

`n` Number of function evaluations

`metric` Name of quality metric

`pdef` Unique id for each combination of `fun`, `d`, `n` and `metric`

`best` Largest value of metric

`median` Median value of metric

`worst` Smallest value of metric

`mean` Average value of metric

`std` Standard deviation of metric

Source

Formerly available at http://web.mysites.ntu.edu.sg/epnsugan/PublicSite/Shared%20Documents/CEC2007-final-pdfs.zip

Examples

```
  ## Not run:
  data(cec2007)
  require(lattice)
  print(dotplot(algo ~ median | fun + metric, cec2007, groups=cec2007$n))

## End(Not run)
```

coalesce *Return first non null argument.*

Description

This function is useful when processing complex arguments with multiple possible defaults based on other arguments that may or may not have been provided.

Usage

```
coalesce(...)
```

Arguments

...	List of values.

Value

First non null element in ....

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

crowding_distance *Crowding Distance*

Description

Calculate crowding distances.

Usage

```
crowding_distance(front)
```

Arguments

front	matrix of function values.

Value

crowding distance for each function value.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

`dominance_matrix` *Calculate the dominance matrix of a set of points*

Description

Calculate the dominance matrix of a set of points

Usage

```
dominance_matrix(points)
```

Arguments

`points`	Matrix containing points one per column.

Value

Dominance matrix

`dominated_hypervolume` *Dominated Hypervolume calculation*

Description

`dominated_hypervolume` calculates the dominated hypervolume of the points in `points`.

Usage

```
dominated_hypervolume(points, ref)

hypervolume_contribution(points, ref)
```

Arguments

`points`	Matrix containing the points one per column.
`ref`	Optional reference point. If not provided the maximum in each dimension is used.

Details

`hypervolume_contribution` calculates the hypervolume contribution of each point.

If no reference point `ref` is given, one is automatically calculated by determening the maximum in each coordinate.

Currently only one general algorithm is implemented due to Fonseca et.al. but work is underway to include others such as the Beume & Rudolph approach as well as the approach by Bradstreet et.al.

The 1D and 2D cases are handle seperately by efficient algorithms. Calculates the exact dominated hypervolume of the points given in `x` subject to the reference point `ref`.

Value

For `dominated_hypervolume` the dominated hypervolume by the points in `points` with respect to the reference point `ref`. For `hypervolume_contribution` a vector giving the hypervolume soley dominated by that point.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

References

This code uses version 1.3 of the hypervolume code available from https://lopez-ibanez.eu/hypervolume. For a description of the algorithm see

Carlos M. Fonseca, Luis Paquete, and Manuel Lopez-Ibanez. *An improved dimension-sweep algorithm for the hypervolume indicator*. In IEEE Congress on Evolutionary Computation, pages 1157-1163, Vancouver, Canada, July 2006.

See Also

`nondominated_points` to extract the pareto front approximation from a given set of points and `nds_hv_selection` for a selection strategy based on the hypervolume contribution of each point.

`emoa_console_logger` *console logger*

Description

Logger object that outputs log messages to the console

Usage

```
emoa_console_logger(...)
```

Arguments

`...`	passed to `emoa_logger`.

Details

This is a wrapper that calls `emoa_logger(output=output,...)` internally and returns that logger.

Value

An `emoa_logger` object.

emoa_control *Basic EMOA control parameters.*

Description

The following control parameters are recognized by `emoa_control`:

logger `emoa_logger` object used to log events.

n Number of parameters, defaults to the length of the longer of `upper` or `lower`.

d Number of dimensions.

Usage

```
emoa_control(f, upper, lower, ..., control, default)
```

Arguments

`f`	Multiobjectve optimization function.
`upper`	Upper bounds of parameter space.
`lower`	Lower bounds of parameter space.
`...`	Further arguments passed to `f`.
`control`	List of control parameters.
`default`	List of default control parameters.

Value

The `control` list with suitably adjusted arguments. Missing control parameters are taken from `default` or, if not present there, from an internal default.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

emoa_logger *generic logger factory*

Description

Basic logger object with a flexible output routine.

Usage

```
emoa_logger(output, every = 10L, ...)
```

Arguments

output	function used to display logging messages.
every	number of steps of the emoa between evaluations.
...	passed to the parent logger factory.

Value

An emoa_logger object.

See Also

emoa_console_logger and emoa_null_logger for convinience wrappers around emoa_logger providing useful defaults.

---

emoa_null_logger *null logger*

Description

Logger object that discards all log events.

Usage

```
emoa_null_logger(...)
```

Arguments

...	ignored.

Value

An emoa_logger object.

`hypervolume_indicator` *Binary quality indicators*

Description

Calculates the quality indicator value of the set of points given in `x` with respect to the set given in `o`. As with all functions in `emoa` that deal with sets of objective values these are stored by column.

Usage

```
hypervolume_indicator(points, o, ref)

epsilon_indicator(points, o)

r1_indicator(points, o, ideal, nadir, lambda, utility = "Tchebycheff")

r2_indicator(points, o, ideal, nadir, lambda, utility = "Tchebycheff")

r3_indicator(points, o, ideal, nadir, lambda, utility = "Tchebycheff")
```

Arguments

`points`	Matrix of points for which to calculate the indicator value stored one per column.
`o`	Matrix of points of the reference set.
`ref`	Reference point, if omitted, the nadir of the point sets is used.
`ideal`	Ideal point of true Pareto front. If omited the ideal of both point sets is used.
`nadir`	Nadir of the true Pareto front. If ommited the nadir of both point sets is used.
`lambda`	Number of weight vectors to use in estimating the utility.
`utility`	Name of utility function.

Value

Value of the quality indicator.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

References

Zitzler, E., Thiele, L., Laumanns, M., Fonseca, C., and Grunert da Fonseca, V (2003): Performance Assessment of Multiobjective Optimizers: An Analysis and Review. IEEE Transactions on Evolutionary Computation, 7(2), 117-132.

inbounds *Clip value to a given range*

Description

Clip x to the interval $[l, u]$. This is useful to enforce box constraints.

Usage

```
inbounds(x, l, u)
```

Arguments

x	Value to clip.
l	Lower limit.
u	Upper limit.

Value

l if x < l, u if x > u else x.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

is_dominated *Pareto dominance checks.*

Description

`is_dominated` returns which points from a set are dominated by another point in the set. `%dominates%` returns true if `x` Pareto dominates `y` and `is_maximally_dominated` returns TRUE for those points which do not dominate any other points.

Usage

```
is_dominated(points)

is_maximally_dominated(points)
```

Arguments

points	Matrix containing points one per column.

Value

For `is_dominated` and `is_maximally_dominated` a boolean vector and for `%dominates%` a single boolean.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

`nds_hv_selection` *Selection strategies*

Description

Selection strategies for EMOA.

Usage

```
nds_hv_selection(values, n = 1, ...)

nds_cd_selection(values, n = 1, ...)
```

Arguments

`values`	Matrix of function values.
`n`	Number of individuals to select for replacement.
`...`	Optional parameters passed to `hypervolume_contribution`.

Details

The currently implemented strategies are nondominated sorting followed by either hypervolume contribution or crowding distance based ranking. Both of these implementations are currently limited to selecting a single individual for replacement.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

nds_rank *Nondominated sorting ranks*

Description

Perform (partial) nondominated sort of the points in `points` and return the rank of each point.

Usage

```
nds_rank(points, partial)

nondominated_ordering(points, partial)
```

Arguments

`points`	Matrix containing points one per column.
`partial`	Optional integer specifying the number of points for which the rank should be calculated. Defaults to all points.

Value

Vector containing the ranks of the first `partial` individuals or all individuals.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

nondominated_points *Nondominated points*

Description

Return those points which are not dominated by another point in `points`. This is the Pareto front approximation of the point set.

Usage

```
nondominated_points(points)
```

Arguments

`points`	Matrix of points, one per column.

Value

Those points in `points` which are not dominated by another point.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

`normalize_points` *Scale point cloud*

Description

Rescale all points to lie in the box bounded by `minval` and `maxval`.

Usage

```
normalize_points(points, minval, maxval)
```

Arguments

`points`	Matrix containing points, one per column.
`minval`	Optional lower limits for the new bounding box.
`maxval`	Optional upper limits for the new bounding box.

Value

Scaled points.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

`pm_control` *Polynomial muation (PM) control parameters*

Description

Control parameters:

pm.n Nu parameter of PM.

pm.p p parameter of PM.

Usage

```
pm_control(f, upper, lower, ..., control, default = list())
```

Arguments

f	Multiobjectve optimization function.
upper	Upper bounds of parameter space.
lower	Lower bounds of parameter space.
...	Further arguments passed to f.
control	List of control parameters.
default	List of default control parameters.

Value

The control list with suitably adjusted arguments. Missing control parameters are taken from default or, if not present there, from an internal default.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

---

pm_operator *Polynomial mutation operator*

Description

Returns a polynomial mutation operator with the given parameters.

Usage

```
pm_operator(n, p, lower, upper)
```

Arguments

n	Distance parameter mutation distribution (η).
p	Probability of one point mutation.
lower	Lower bounds of parameter space.
upper	Upper bounds of parameter space.

Value

Function which implements the specified mutation operator.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

sbx_control *Simulated binary crossover (SBX) control parameters*

Description

`sbx_control` interprets the following parameters used to control the behaviour of the simulated binary crossover operator (see `sbx_operator`):

sbx.n Nu parameter of SBX.

sbx.p p parameter of SBX.

Usage

```
sbx_control(f, upper, lower, ..., control, default = list())
```

Arguments

`f`	Multiobjectve optimization function.
`upper`	Upper bounds of parameter space.
`lower`	Lower bounds of parameter space.
`...`	Further arguments passed to `f`.
`control`	List of control parameters.
`default`	List of default control parameters.

Value

The `control` list with suitably adjusted arguments. Missing control parameters are taken from `default` or, if not present there, from an internal default.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

sbx_operator *Simulated binary crossover operator*

Description

Returns a simulated binary crossover operator with the given parameters.

Usage

```
sbx_operator(n, p, lower, upper)
```

Arguments

n	Distance parameter of crossover distribution (η).
p	Probability of one point crossover.
lower	Lower bounds of parameter space.
upper	Upper bounds of parameter space.

Value

Function with one parameter x which takes a matrix containing two sets of parameters and returns a matrix of two sets of parameters which resulted from the crossover operation. As with all emoa functions, the parameter sets are stored in the columns of x. x should therefore always have two columns and a warning will be given if it has more than two columns.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

See Also

pm_operator

---

steady_state_emoa_control

Steady state EMOA parameters

Description

steady_state_emoa_control interprets the following control parameters:

mu Population size.

maxeval Maximum number of function evaluations to use.

Usage

```
steady_state_emoa_control(f, upper, lower, ..., control, default = list())
```

Arguments

f	Multiobjectve optimization function.
upper	Upper bounds of parameter space.
lower	Lower bounds of parameter space.
...	Further arguments passed to f.
control	List of control parameters.
default	List of default control parameters.

Value

The `control` list with suitably adjusted arguments. Missing control parameters are taken from `default` or, if not present there, from an internal default.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

---

sympart *Functions from the CEC 2007 EMOA competition.*

Description

Functions from the CEC 2007 EMOA competition.

Usage

```
sympart(x)
```

Arguments

`x`	Parmater vector.

Value

Function value.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

UF1 *Functions from the CEC 2009 EMOA competition.*

Description

Functions from the CEC 2009 EMOA competition.

Usage

```
UF1(x)

UF2(x)

UF3(x)

UF4(x)

UF5(x)

UF6(x)

UF7(x)

UF8(x)

UF9(x)

UF10(x)
```

Arguments

x	Parmater vector.

Value

Function value.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

---

unary_r2_indicator *Unary R2 indicator*

Description

Unary R2 indicator

Usage

```
unary_r2_indicator(points, weights, ideal)
```

Arguments

points	Matrix of points for which to calculate the indicator value stored one per column.
weights	Matrix of weight vectors stored one per column.
ideal	Ideal point of true Pareto front. If omited the ideal of points is used.

Value

Value of unary R2 indicator.

Author(s)

Olaf Mersmann <olafm@p-value.net>

---

which_points_on_edge *Determine which points are on the edge of a Pareto-front approximation.*

Description

Determine which points are on the edge of a Pareto-front approximation.

Usage

```
which_points_on_edge(front)
```

Arguments

front	Pareto-front approximation.

Value

An integer vector containing the indicies of the points (columns) of front which are on the edge of the Pareto-front approximation.

Author(s)

Olaf Mersmann <olafm@statistik.tu-dortmund.de>

Index