Package ‘mcga’

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Description Machine coded genetic algorithm (MCGA) is a fast tool for real-valued optimization problems. It uses the byte representation of variables rather than real-values. It performs the classical crossover operations (uniform) on these byte representations. Mutation operator is also similar to classical mutation operator, which is to say, it changes a randomly selected byte value of a chromosome by +1 or -1 with probability 1/2. In MCGAs there is no need for encoding-decoding process and the classical operators are directly applicable on real-values. It is fast and can handle a wide range of a search space with high precision. Using a 256-unary alphabet is the main disadvantage of this algorithm but a moderate size population is convenient for many problems. Package also includes multi_mcga function for multi objective optimization problems. This function sorts the chromosomes using their ranks calculated from the non-dominated sorting algorithm.

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Contents

`mcga-package` *Machine Coded Genetic Algorithms for Real-valued Optimization Problems*

Description

Machine coded genetic algorithm (MCGA) is a fast tool for real-valued optimization problems. It uses the byte representation of variables rather than real-values. It performs the classical crossover operations (uniform) on these byte representations. Mutation operator is also similar to classical mutation operator, which is to say, it changes a randomly selected byte value of a chromosome by +1 or -1 with probability 1/2. In MCGAs there is no need for encoding-decoding process and the classical operators are directly applicable on real-values. It is fast and can handle a wide range of a search space with high precision. Using a 256-unary alphabet is the main disadvantage of this algorithm but a moderate size population is convenient for many problems.

Author(s)

Mehmet Hakan Satman

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Examples

```
## Not run:
# A sample optimization problem
# Min f(xi) = (x1-7)^2 + (x2-77)^2 + (x3-777)^2 + (x4-7777)^2 + (x5-77777)^2
# The range of xi is unknown. The solution is
# x1 = 7
# x2 = 77
# x3 = 777
# x4 = 7777
# x5 = 77777
# Min f(xi) = 0
require("mcga")
 f<-function(x){
    return ((x[1]-7)^2 + (x[2]-77)^2 +(x[3]-777)^2 +(x[4]-7777)^2 +(x[5]-77777)^2)
 }
 m <- mcga( popsize=200,
chsize=5,
minval=0.0,
maxval=999999999.9,
maxiter=2500,
crossprob=1.0,
mutateprob=0.01,
evalFunc=f)

 cat("Best chromosome:\n")
 print(m$population[1,])
 cat("Cost: ",m$costs[1],"\n")

## End(Not run)
```

arithmetic_crossover *Performs arithmetic crossover operation on a pair of two selected parent candidate solutions*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `crossover=` is set to `arithmetic_crossover` than the arithmetic crossover operator is applied in the genetic search. `arithmetic_crossover` generates offspring using the weighted mean of parents' genes. Weights are drawn randomly.

Usage

```
arithmetic_crossover(object, parents, ...)
```

Arguments

`object`	A `GA::ga` object
`parents`	Indices of the selected parents
`...`	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- ga(type="real-valued", fitness = f, popSize = 100, maxiter = 100,
           min = rep(-50,5), max = rep(50,5), crossover = arithmetic_crossover)
print(myga@solution)
```

`blx_crossover` *Performs blx (blend) crossover operation on a pair of two selected parent candidate solutions*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `crossover=` is set to `blx_crossover` than the blx crossover operator is applied in the genetic search.

Usage

```
blx_crossover(object, parents, ...)
```

Arguments

`object`	A `GA::ga` object
`parents`	Indices of the selected parents
`...`	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- ga(type="real-valued", fitness = f, popSize = 100, maxiter = 100,
           min = rep(-50,5), max = rep(50,5), crossover = blx_crossover)
print(myga@solution)
```

`ByteCodeMutation` *Mutation operator for byte representation of double values*

Description

This function is a C++ wrapper for mutating byte representation of a given candidate solution

Usage

```
ByteCodeMutation(bytes1, pmutation)
```

Arguments

`bytes1`	A vector of bytes of a candidate solution
`pmutation`	Probability of mutation

Value

Byte vector of mutated solution

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

ByteCodeMutationUsingDoubles

Examples

```
set.seed(1246)
print(pi)
bytes <- DoubleToBytes(pi)
mutated.bytes <- ByteCodeMutation(bytes, 0.10)
new.var <- BytesToDouble(mutated.bytes)
print(new.var)
```

`ByteCodeMutationUsingDoubles` *Mutation operator for byte representation of double values*

Description

This function is a C++ wrapper for mutating byte representation of a given candidate solution

Usage

```
ByteCodeMutationUsingDoubles(d, pmutation)
```

Arguments

`d`	A vector of doubles
`pmutation`	Probability of mutation

Value

Double vector of mutated solution

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

ByteCodeMutation

Examples

```
set.seed(1246)
print(pi)
print(exp(1))
new.var <- ByteCodeMutationUsingDoubles(c(pi, exp(1)), 0.10)
print(new.var)
```

ByteCodeMutationUsingDoublesRandom

Mutation operator for byte representation of double values

Description

This function is a C++ wrapper for mutating byte representation of a given candidate solution. This mutation operator randomly changes a byte in the range of [0,255].

Usage

```
ByteCodeMutationUsingDoublesRandom(d, pmutation)
```

Arguments

d	A vector of doubles
pmutation	Probability of mutation

Value

Double vector of mutated solution

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

ByteCodeMutation

Examples

```
set.seed(1246)
print(pi)
print(exp(1))
new.var <- ByteCodeMutationUsingDoublesRandom(c(pi, exp(1)), 0.10)
print(new.var)
```

`BytesToDouble` *Converting* `sizeof(double)` *bytes to a double value*

Description

This function converts `sizeof(double)` bytes to a double typed value

Usage

```
BytesToDouble(x)
```

Arguments

`x`	A vector of bytes (unsigned chars in C++)

Value

Corresponding `double` typed value for a given vector of bytes

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

DoubleVectorToBytes

DoubleToBytes

ByteVectorToDoubles

Examples

```
print(BytesToDouble(DoubleToBytes(56.43)))
```

`ByteVectorToDoubles` *Converting p* * `sizeof(double)` *bytes to a vector of p double values*

Description

This function converts a byte vector to a vector of doubles

Usage

```
ByteVectorToDoubles(b)
```

Arguments

`b`	A vector of bytes (unsigned chars in C++)

Value

Corresponding vector of `double` typed values for a given vector of bytes

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

DoubleVectorToBytes

BytesToDouble

ByteVectorToDoubles

Examples

```
a <- DoubleVectorToBytes(c(56.54, 89.7666, 98.565))
b <- ByteVectorToDoubles(a)
print(b)
```

`byte_crossover` *Performs crossover operation on a pair of two selected parent candidate solutions*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `crossover=` is set to `byte_crossover` than the byte-coded crossover operator is applied in the genetic search. In `mcga2` function, the hard-coded crossover parameter is set to byte_crossover by definition. `byte_crossover` function simply takes two double vectors (parents) and combines the bytes of doubles using a Uniform distribution with parameters 0 and 1.

Usage

```
byte_crossover(object, parents, ...)
```

Arguments

`object`	A `GA::ga` object
`parents`	Indices of the selected parents
`...`	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

See Also

mcga2

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- GA::ga(type="real-valued", fitness = f, popSize = 100, maxiter = 200,
              lower = rep(-50,5), upper = rep(50,5), crossover = byte_crossover,
              mutation = byte_mutation)
print(myga@solution)
```

---

byte_crossover_1p — *Performs one-point crossover operation on a pair of two selected parent candidate solutions*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `crossover=` is set to `byte_crossover_1p` than the byte-coded one-point crossover operator is applied in the genetic search. In `mcga2` function, the hard-coded crossover parameter is set to byte_crossover by definition. `byte_crossover_1p` function simply takes two double vectors (parents) and combines the bytes of doubles using given cut-point.

Usage

```
byte_crossover_1p(object, parents, ...)
```

Arguments

`object`	A `GA::ga` object
`parents`	Indices of the selected parents
`...`	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

See Also

mcga2

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- GA::ga(type="real-valued", fitness = f, popSize = 100, maxiter = 200,
              min = rep(-50,5), max = rep(50,5), crossover = byte_crossover_1p,
              mutation = byte_mutation)
print(myga@solution)
```

---

byte_crossover_2p — *Performs two-point crossover operation on a pair of two selected parent candidate solutions*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `crossover=` is set to `byte_crossover_2p` than the byte-coded two-point crossover operator is applied in the genetic search. In `mcga2` function, the hard-coded crossover parameter is set to byte_crossover by definition. `byte_crossover_2p` function simply takes two double vectors (parents) and combines the bytes of doubles using given cutpoint1 and cutpoint2.

Usage

```
byte_crossover_2p(object, parents, ...)
```

Arguments

`object`	A `GA::ga` object
`parents`	Indices of the selected parents
`...`	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

See Also

mcga2

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- GA::ga(type="real-valued", fitness = f, popSize = 100, maxiter = 200,
              min = rep(-50,5), max = rep(50,5), crossover = byte_crossover_2p,
              mutation = byte_mutation)
print(myga@solution)
```

`byte_mutation` *Performs mutation operation on a given double vector*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `mutation=` is set to `byte_mutation` than the byte-coded mutation operator is applied in the genetic search. In `mcga2` function, the hard-coded mutation parameter is set to byte_mutation by definition. Byte-mutation function simply takes an double vector and changes bytes of this values by +1 or -1 using the pre-determined mutation probabilty.

Usage

```
byte_mutation(object, parent, ...)
```

Arguments

`object`	A `GA::ga` object
`parent`	Index of the candidate solution of the current population
`...`	Additional arguments to be passed to the function

Value

Mutated double vector

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- GA::ga(type="real-valued", fitness = f, popSize = 100, maxiter = 200,
              min = rep(-50,5), max = rep(50,5), crossover = byte_crossover,
              mutation = byte_mutation)
print(myga@solution)
```

---

byte_mutation_dynamic *Performs mutation operation on a given double vector using dynamic mutation probabilities*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `mutation=` is set to `byte_mutation_dynamic` than the byte-coded mutation operator is applied in the genetic search. In `mcga2` function, the hard-coded mutation parameter is set to byte_mutation by definition. Byte-mutation function simply takes an double vector and changes bytes of this values by +1 or -1 using the dynamically decreased and pre-determined mutation probabilty.

Usage

```
byte_mutation_dynamic(object, parent, ...)
```

Arguments

`object`	A `GA::ga` object
`parent`	Index of the candidate solution of the current population
`...`	Additional arguments to be passed to the function

Value

Mutated double vector

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- GA::ga(type="real-valued", fitness = f, popSize = 100, maxiter = 200,
              min = rep(-50,5), max = rep(50,5), crossover = byte_crossover,
              mutation = byte_mutation_dynamic, pmutation = 0.10)
print(myga@solution)
```

---

byte_mutation_random *Performs mutation operation on a given double vector*

Description

This function is not called directly but is given as a parameter in GA::ga function. In GA::ga, if the parameter mutation= is set to byte_mutation_random than the byte-coded mutation operator is applied in the genetic search. In mcga2 function, the hard-coded mutation parameter is set to byte_mutation by definition. This function simply takes an double vector and changes bytes randomly in the range of [0,255] using the pre-determined mutation probabilty.

Usage

```
byte_mutation_random(object, parent, ...)
```

Arguments

object	A GA::ga object
parent	Index of the candidate solution of the current population
...	Additional arguments to be passed to the function

Value

Mutated double vector

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- GA::ga(type="real-valued", fitness = f, popSize = 100, maxiter = 200,
              min = rep(-50,5), max = rep(50,5), crossover = byte_crossover,
              mutation = byte_mutation_random, pmutation = 0.20)
print(myga@solution)
```

---

byte_mutation_random_dynamic

Performs mutation operation on a given double vector with dynamic mutation probabilities

---

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `mutation=` is set to `byte_mutation_random_dynamic` than the byte-coded mutation operator with dynamic probabilities is applied in the genetic search. In `mcga2` function, the hard-coded mutation parameter is set to byte_mutation by definition. This function simply takes an double vector and changes bytes randomly in the range of [0,255] using the descrasing values of pre-determined mutation probabilty by generations.

Usage

```
byte_mutation_random_dynamic(object, parent, ...)
```

Arguments

`object`	A `GA::ga` object
`parent`	Index of the candidate solution of the current population
`...`	Additional arguments to be passed to the function

Value

Mutated double vector

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
# Increase popSize and maxiter for more precise solutions
myga <- GA::ga(type="real-valued", fitness = f, popSize = 100, maxiter = 200,
              min = rep(-50,5), max = rep(50,5), crossover = byte_crossover,
              mutation = byte_mutation_random_dynamic, pmutation = 0.20)
print(myga@solution)
```

`DoubleToBytes` *Byte representation of a* `double` *typed variable*

Description

This function returns a vector of byte values with the length of `sizeof(double)` for a given `double` typed value

Usage

```
DoubleToBytes(x)
```

Arguments

`x`	A double typed value

Value

A vector of byte values with the length of `sizeof(double)` for a given `double` typed value

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

DoubleVectorToBytes

BytesToDouble

ByteVectorToDoubles

Examples

```
print(DoubleToBytes(56.43))
```

`DoubleVectorToBytes` *Byte representation of a vector of `double` typed variables*

Description

This function returns a vector of byte values for a given vector of `double` typed values

Usage

```
DoubleVectorToBytes(d)
```

Arguments

`d`	A vector of double typed values

Value

returns a vector of byte values for a given vector of `double` typed values

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

DoubleToBytes

BytesToDouble

ByteVectorToDoubles

Examples

```
print(DoubleVectorToBytes(c(56.54, 89.7666, 98.565)))
```

`EnsureBounds` *Altering vector of doubles to satisfy boundary constraints*

Description

Byte based crossover and mutation operators can generate variables out of bounds of the decision variables. This function controls if variables are between their lower and upper bounds and if not, draws random numbers between these ranges. This function directly modifies the argument `doubles` and does not return a value.

Usage

```
EnsureBounds(doubles, mins, maxs)
```

Arguments

`doubles`	A vector of doubles
`mins`	A vector of lower bounds of decision variables
`maxs`	A vector of upper bounds of decision variables

Value

Function directly modifies the argument `doubles` and does not return a result.

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

byte_crossover

byte_mutation

mcga2

Examples

```
set.seed(1234)
x <- runif(10)
print(x)
# [1] 0.113703411 0.622299405 0.609274733 0.623379442 0.860915384 0.640310605
# [7] 0.009495756 0.232550506 0.666083758 0.514251141
EnsureBounds(x, mins=rep(0,10), maxs=rep(0.2,10))
print(x)
# [1] 0.113703411 0.138718258 0.108994967 0.056546717 0.184686697 0.058463168
# [7] 0.009495756 0.167459126 0.057244657 0.053364156
```

`flat_crossover` *Performs flat crossover operation on a pair of two selected parent candidate solutions*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `crossover=` is set to `flat_crossover` than the flat crossover operator is applied in the genetic search. `flat_crossover` draws a random number between parents' genes and returns a pair of generated offspring

Usage

```
flat_crossover(object, parents, ...)
```

Arguments

object	A GA::ga object
parents	Indices of the selected parents
...	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- ga(type="real-valued", fitness = f, popSize = 100, maxiter = 100,
           min = rep(-50,5), max = rep(50,5), crossover = flat_crossover)
print(myga@solution)
```

---

linear_crossover — *Performs linear crossover operation on a pair of two selected parent candidate solutions*

Description

This function is not called directly but is given as a parameter in GA::ga function. In GA::ga, if the parameter crossover= is set to linear_crossover than the linear crossover operator is applied in the genetic search. linear_crossover generates three offspring and performs a selection mechanism to determine best two of them.

Usage

```
linear_crossover(object, parents, ...)
```

Arguments

object	A GA::ga object
parents	Indices of the selected parents
...	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- ga(type="real-valued", fitness = f, popSize = 100, maxiter = 100,
           min = rep(-50,5), max = rep(50,5), crossover = linear_crossover)
print(myga@solution)
```

MaxDouble *Maximum value of a* `double` *typed variable*

Description

Maximum value of a `double` typed variable

Usage

```
MaxDouble()
```

Value

Returns maximum value of a `double` typed variable in C++ compiler

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
print(MaxDouble())
```

mcga *Performs machine coded genetic algorithms on a function subject to be minimized.*

Description

Machine coded genetic algorithm (MCGA) is a fast tool for real-valued optimization problems. It uses the byte representation of variables rather than real-values. It performs the classical crossover operations (uniform) on these byte representations. Mutation operator is also similar to classical mutation operator, which is to say, it changes a randomly selected byte value of a chromosome by +1 or -1 with probability 1/2. In MCGAs there is no need for encoding-decoding process and the classical operators are directly applicable on real-values. It is fast and can handle a wide range of a search space with high precision. Using a 256-unary alphabet is the main disadvantage of this algorithm but a moderate size population is convenient for many problems.

Usage

```
mcga(popsize, chsize, crossprob = 1.0, mutateprob = 0.01,
 elitism = 1, minval, maxval, maxiter = 10, evalFunc)
```

Arguments

popsize	Number of chromosomes.
chsize	Number of parameters.
crossprob	Crossover probability. By default it is 1.0
mutateprob	Mutation probability. By default it is 0.01
elitism	Number of best chromosomes to be copied directly into next generation. By default it is 1
minval	The lower bound of the randomized initial population. This is not a constraint for parameters.
maxval	The upper bound of the randomized initial population. This is not a constraint for parameters.
maxiter	The maximum number of generations. By default it is 10
evalFunc	An R function. By default, each problem is a minimization.

Value

population	Sorted population resulted after generations
costs	Cost values for each chromosomes in the resulted population

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

Examples

```
# A sample optimization problem
# Min f(xi) = (x1-7)^2 + (x2-77)^2 + (x3-777)^2 + (x4-7777)^2 + (x5-77777)^2
# The range of xi is unknown. The solution is
# x1 = 7
# x2 = 77
# x3 = 777
# x4 = 7777
# x5 = 77777
# Min f(xi) = 0
require("mcga")
 f<-function(x){
    return ((x[1]-7)^2 + (x[2]-77)^2 +(x[3]-777)^2 +(x[4]-7777)^2 +(x[5]-77777)^2)
 }
 m <- mcga( popsize=200,
chsize=5,
minval=0.0,
maxval=999999999.9,
maxiter=2500,
crossprob=1.0,
mutateprob=0.01,
evalFunc=f)

 cat("Best chromosome:\n")
 print(m$population[1,])
 cat("Cost: ",m$costs[1],"\n")
```

---

mcga2 *Performs a machine-coded genetic algorithm search for a given optimization problem*

Description

mcga2 is the improvement version of the standard mcga function as it is based on the `GA::ga` function. The `byte_crossover` and the `byte_mutation` operators are the main reproduction operators and these operators uses the byte representations of parents in the computer memory.

Usage

```
mcga2(fitness, ..., min, max,
  population = gaControl("real-valued")$population,
  selection = gaControl("real-valued")$selection,
  crossover = byte_crossover, mutation = byte_mutation, popSize = 50,
  pcrossover = 0.8, pmutation = 0.1, elitism = base::max(1, round(popSize
```

```
  * 0.05)), maxiter = 100, run = maxiter, maxFitness = Inf,
  names = NULL, parallel = FALSE, monitor = gaMonitor, seed = NULL)
```

Arguments

fitness	The goal function to be maximized
...	Additional arguments to be passed to the fitness function
min	Vector of lower bounds of variables
max	Vector of upper bounds of variables
population	Initial population. It is gaControl("real-valued")$population by default.
selection	Selection operator. It is gaControl("real-valued")$selection by default.
crossover	Crossover operator. It is byte_crossover by default.
mutation	Mutation operator. It is byte_mutation by default. Other values can be given including byte_mutation_random, byte_mutation_dynamic and byte_mutation_random_dynamic
popSize	Population size. It is 50 by default
pcrossover	Probability of crossover. It is 0.8 by default
pmutation	Probability of mutation. It is 0.1 by default
elitism	Number of elitist solutions. It is base::max(1, round(popSize*0.05)) by default
maxiter	Maximum number of generations. It is 100 by default
run	The genetic search is stopped if the best solution has not any improvements in last run generations. By default it is maxiter
maxFitness	Upper bound of the fitness function. By default it is Inf
names	Vector of names of the variables. By default it is NULL
parallel	If TRUE, fitness calculations are performed parallel. It is FALSE by default
monitor	The monitoring function for printing some information about the current state of the genetic search. It is gaMonitor by default
seed	The seed for random number generating. It is NULL by default

Value

Returns an object of class ga-class

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

M.H.Satman (2013), Machine Coded Genetic Algorithms for Real Parameter Optimization Problems, Gazi University Journal of Science, Vol 26, No 1, pp. 85-95

Luca Scrucca (2013). GA: A Package for Genetic Algorithms in R. Journal of Statistical Software, 53(4), 1-37.

See Also

GA::ga

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- mcga2(fitness = f, popSize = 100, maxiter = 300,
              min = rep(-50,5), max = rep(50,5))
print(myga@solution)
```

---

multi_mcga *Performs multi objective machine coded genetic algorithms.*

Description

Machine coded genetic algorithm (MCGA) is a fast tool for real-valued optimization problems. It uses the byte representation of variables rather than real-values. It performs the classical crossover operations (uniform) on these byte representations. Mutation operator is also similar to classical mutation operator, which is to say, it changes a randomly selected byte value of a chromosome by +1 or -1 with probability 1/2. In MCGAs there is no need for encoding-decoding process and the classical operators are directly applicable on real-values. It is fast and can handle a wide range of a search space with high precision. Using a 256-unary alphabet is the main disadvantage of this algorithm but a moderate size population is convenient for many problems.

This function performs multi objective optimization using the same logic underlying the mcga. Chromosomes are sorted by their objective values using a non-dominated sorting algorithm.

Usage

```
multi_mcga(popsize, chsize, crossprob = 1.0, mutateprob = 0.01,
   elitism = 1, minval, maxval, maxiter = 10, numfunc, evalFunc)
```

Arguments

`popsize`	Number of chromosomes.
`chsize`	Number of parameters.
`crossprob`	Crossover probability. By default it is 1.0
`mutateprob`	Mutation probability. By default it is 0.01
`elitism`	Number of best chromosomes to be copied directly into next generation. By default it is 1
`minval`	The lower bound of the randomized initial population. This is not a constraint for parameters.
`maxval`	The upper bound of the randomized initial population. This is not a constraint for parameters.

maxiter	The maximum number of generations. By default it is 10.
numfunc	Number of objective functions.
evalFunc	An R function. By default, each problem is a minimization. This function must return a cost vector with dimension of numfunc. Each element of this vector points to the corresponding function to optimize.

Value

population	Sorted population resulted after generations
costs	Cost values for each chromosomes in the resulted population
ranks	Calculated ranks using a non-dominated sorting for each chromosome

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

Deb, K. (2000). An efficient constraint handling method for genetic algorithms. Computer methods in applied mechanics and engineering, 186(2), 311-338.

Examples

```
## Not run:
 # We have two objective functions.
 f1<-function(x){
   return(sin(x))
 }

 f2<-function(x){
   return(sin(2*x))
 }

 # This function returns a vector of cost functions for a given x sent from mcga
 f<-function(x){
   return ( c( f1(x), f2(x)) )
 }

 # main loop
 m<-multi_mcga(popsize=200, chsize=1, minval= 0, elitism=2,
        maxval= 2.0 * pi, maxiter=1000, crossprob=1.0,
      mutateprob=0.01, evalFunc=f, numfunc=2)

 # Points show best five solutions.
 curve(f1, 0, 2*pi)
 curve(f2, 0, 2*pi, add=TRUE)

 p <- m$population[1:5,]
 points(p, f1(p))
 points(p, f2(p))
```

```
## End(Not run)
```

`OnePointCrossOver` *One Point Crossover operation on the two vectors of bytes*

Description

This function is a C++ wrapper for crossing-over of two byte vectors of candidate solutions

Usage

```
OnePointCrossOver(bytes1, bytes2, cutpoint)
```

Arguments

`bytes1`	A vector of bytes of the first parent
`bytes2`	A vector of bytes of the second parent
`cutpoint`	Cut-point for the single point crossing-over

Value

List of two byte vectors of offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

UniformCrossOver

UniformCrossOverOnDoublesUsingBytes

Examples

```
b1 <- DoubleVectorToBytes(c(56.54, 89.7666, 98.565))
b2 <- DoubleVectorToBytes(c(79.76, 56.4443, 34.22121))
result <- OnePointCrossOver(b1,b2, round(runif(1,1,SizeOfDouble() * 3)))
print(ByteVectorToDoubles(result[[1]]))
print(ByteVectorToDoubles(result[[2]]))
```

`OnePointCrossOverOnDoublesUsingBytes`
One-point Crossover operation on the two vectors of doubles using their byte representations

Description

This function is a C++ wrapper for crossing-over of two double vectors of candidate solutions using their byte representations

Usage

```
OnePointCrossOverOnDoublesUsingBytes(d1, d2, cutpoint)
```

Arguments

`d1`	A vector of doubles of the first parent
`d2`	A vector of doubles of the second parent
`cutpoint`	An integer between 1 and chromosome length for crossover cutting

Value

List of two double vectors of offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

OnePointCrossOver

UniformCrossOverOnDoublesUsingBytes

Examples

```
d1 <- runif(3)
d2 <- runif(3)
cutp <- sample(1:(length(d1)*SizeOfDouble()), 1)[1]
offspring <- OnePointCrossOverOnDoublesUsingBytes(d1,d2, cutp)
print("Parents:")
print(d1)
print(d2)
print("Offspring:")
print(offspring[[1]])
print(offspring[[2]])
```

`sbx_crossover` *Performs sbx (simulated binary) crossover operation on a pair of two selected parent candidate solutions*

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `crossover=` is set to `sbx_crossover` than the sbx crossover operator is applied in the genetic search. sbx_crossover mimics the classical single-point crossover operator in binary genetic algorithms.

Usage

```
sbx_crossover(object, parents, ...)
```

Arguments

`object`	A `GA::ga` object
`parents`	Indices of the selected parents
`...`	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

References

Deb, Kalyanmoy, and Ram Bhushan Agrawal. "Simulated binary crossover for continuous search space." Complex systems 9.2 (1995): 115-148.

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- ga(type="real-valued", fitness = f, popSize = 100, maxiter = 100,
           min = rep(-50,5), max = rep(50,5), crossover = sbx_crossover)
print(myga@solution)
```

`SizeOfDouble` *Byte-length of a* `double` *typed variable*

Description

Byte-length of a `double` typed variable in computer memory

Usage

```
SizeOfDouble()
```

Value

Returns the byte-length of a `double` typed variable in computer memory

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
print(SizeOfDouble())
```

`SizeOfInt` *Byte-length of a* `int` *typed variable*

Description

Byte-length of a `int` typed variable in computer memory

Usage

```
SizeOfInt()
```

Value

Returns the byte-length of a `int` typed variable in computer memory

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
print(SizeOfInt())
```

`SizeOfLong` *Byte-length of a `long` typed variable*

Description

Byte-length of a `long` typed variable in computer memory

Usage

```
SizeOfLong()
```

Value

Returns the byte-length of a `long` typed variable in computer memory

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
print(SizeOfLong())
```

`TwoPointCrossOver` *Two Point Crossover operation on the two vectors of bytes*

Description

This function is a C++ wrapper for crossing-over of two byte vectors of candidate solutions

Usage

```
TwoPointCrossOver(bytes1, bytes2, cutpoint1, cutpoint2)
```

Arguments

`bytes1`	A vector of bytes of the first parent
`bytes2`	A vector of bytes of the second parent
`cutpoint1`	First cut-point for the single point crossing-over
`cutpoint2`	Second cut-point for the single point crossing-over

Value

List of two byte vectors of offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

OnePointCrossOver

OnePointCrossOverOnDoublesUsingBytes

UniformCrossOverOnDoublesUsingBytes

Examples

```
b1 <- DoubleVectorToBytes(c(56.54, 89.7666, 98.565))
b2 <- DoubleVectorToBytes(c(79.76, 56.4443, 34.22121))
cutpoints <- sort(sample(1:(length(b1)*SizeOfDouble()), 2, replace = FALSE))
result <- TwoPointCrossOver(b1,b2, cutpoints[1], cutpoints[2])
print(ByteVectorToDoubles(result[[1]]))
print(ByteVectorToDoubles(result[[2]]))
```

TwoPointCrossOverOnDoublesUsingBytes

Two-point Crossover operation on the two vectors of doubles using their byte representations

---

Description

This function is a C++ wrapper for crossing-over of two double vectors of candidate solutions using their byte representations

Usage

```
TwoPointCrossOverOnDoublesUsingBytes(d1, d2, cutpoint1, cutpoint2)
```

Arguments

`d1`	A vector of doubles of the first parent
`d2`	A vector of doubles of the second parent
`cutpoint1`	An integer between 1 and chromosome length for crossover cutting
`cutpoint2`	An integer between cutpoint1 and chromosome length for crossover cutting

Value

List of two double vectors of offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

TwoPointCrossOver

OnePointCrossOver

UniformCrossOver

OnePointCrossOverOnDoublesUsingBytes

Examples

```
d1 <- runif(3)
d2 <- runif(3)
cutpoints <- sort(sample(1:(length(d1)*SizeOfDouble()), 2, replace = FALSE))
offspring <- TwoPointCrossOverOnDoublesUsingBytes(d1,d2,cutpoints[1], cutpoints[2])
print("Parents:")
print(d1)
print(d2)
print("Offspring:")
print(offspring[[1]])
print(offspring[[2]])
```

---

unfair_average_crossover

Performs unfair average crossover operation on a pair of two selected parent candidate solutions

---

Description

This function is not called directly but is given as a parameter in `GA::ga` function. In `GA::ga`, if the parameter `crossover=` is set to `unfair_average_crossover` than the unfair average crossover operator is applied in the genetic search.

Usage

```
unfair_average_crossover(object, parents, ...)
```

Arguments

`object`	A `GA::ga` object
`parents`	Indices of the selected parents
`...`	Additional arguments to be passed to the function

Value

List of two generated offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

Examples

```
f <- function(x){
  return(-sum( (x-5)^2 ) )
}
myga <- ga(type="real-valued", fitness = f, popSize = 100, maxiter = 100,
           min = rep(-50,5), max = rep(50,5), crossover = unfair_average_crossover)
print(myga@solution)
```

UniformCrossOver — *Uniform Crossover operation on the two vectors of bytes*

Description

This function is a C++ wrapper for crossing-over of two byte vectors of candidate solutions

Usage

```
UniformCrossOver(bytes1, bytes2)
```

Arguments

`bytes1`	A vector of bytes of the first parent
`bytes2`	A vector of bytes of the second parent

Value

List of two byte vectors of offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

OnePointCrossOver

UniformCrossOverOnDoublesUsingBytes

Examples

```
b1 <- DoubleVectorToBytes(c(56.54, 89.7666, 98.565))
b2 <- DoubleVectorToBytes(c(79.76, 56.4443, 34.22121))
result <- UniformCrossOver(b1,b2)
print(ByteVectorToDoubles(result[[1]]))
print(ByteVectorToDoubles(result[[2]]))
```

UniformCrossOverOnDoublesUsingBytes

Uniform Crossover operation on the two vectors of doubles using their byte representations

Description

This function is a C++ wrapper for crossing-over of two double vectors of candidate solutions using their byte representations

Usage

```
UniformCrossOverOnDoublesUsingBytes(d1, d2)
```

Arguments

d1	A vector of doubles of the first parent
d2	A vector of doubles of the second parent

Value

List of two double vectors of offspring

Author(s)

Mehmet Hakan Satman - mhsatman@istanbul.edu.tr

See Also

OnePointCrossOver

OnePointCrossOverOnDoublesUsingBytes

Examples

```
d1 <- runif(3)
d2 <- runif(3)
offspring <- UniformCrossOverOnDoublesUsingBytes(d1,d2)
print("Parents:")
print(d1)
print(d2)
print("Offspring:")
print(offspring[[1]])
print(offspring[[2]])
```

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