

Package ‘xegaDfGene’

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Title Gene Operations for Real-Coded Genes

Version 1.0.0.3

Description Representation-dependent gene-level operations for genetic and evolutionary algorithms with real-coded genes are collected in this package. The common feature of the gene operations is that all of them are useful for derivation-free optimization algorithms. At the moment the package implements initialization, mutation, crossover, and replication operations for differential evolution as described in Price, Kenneth V., Storn, Rainer M. and Lampinen, Jouni A. (2005) <[doi:10.1007/3-540-31306-0](https://doi.org/10.1007/3-540-31306-0)>.

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URL <https://github.com/ageyerschulz/xegaDfGene>

Encoding UTF-8

RoxygenNote 7.3.2

Suggests testthat (>= 3.0.0)

Imports xegaSelectGene

NeedsCompilation no

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ConstScaleFactor	<i>Constant scale factor for differential evolution.</i>
------------------	--

Description

Constant scale factor for differential evolution.

Usage

ConstScaleFactor(1F)

Arguments

1F Local configuration.

Value

A constant scale factor.

See Also

Other Scale Factor: [UniformRandomScaleFactor\(\)](#)

Examples

```
parm<-function(x){function() {return(x)}}
1F<-list()
1F$ScaleFactor1<-parm(0.90)
ConstScaleFactor(1F)
1F$ScaleFactor1<-parm(1.10)
ConstScaleFactor(1F)
```

lFxegaDfGene

Generate local functions and objects

Description

lFxegaDfGene() is the list of functions containing a definition of all local objects required for the use of evaluation functions. We reference this object as local configuration. When adding additional functions, this list must be extended by the constant (functions) needed to configure them.

Usage

```
lFxegaDfGene
```

Format

An object of class list of length 32.

Details

We use the local configuration for:

1. Replacing all constants with constant functions.
Rationale: We need one formal argument (the local function list lF) and we can dispatch multiple functions. E.g., lF\$verbose().
2. Dynamically binding a local function with a definition from a proper function factory. E.g., the selection methods lF\$SelectGene() and lF\$SelectMate().
3. Gene representations requiring special functions to handle them: lF\$InitGene(), lF\$DecodeGene(), lF\$EvalGene(), lF\$ReplicateGene(), ...

See Also

Other Configuration: [xegaDfCrossoverFactory\(\)](#), [xegaDfGeneMapFactory\(\)](#), [xegaDfMutationFactory\(\)](#), [xegaDfReplicationFactory\(\)](#), [xegaDfScaleFactorFactory\(\)](#)

UniformRandomScaleFactor

Uniform random scale factor for differential evolution.

Description

The scale factor is drawn from 0.000001 to 1.0.

Usage

```
UniformRandomScaleFactor(lF)
```

Arguments

1F Local configuration.

Value

A constant scale factor.

See Also

Other Scale Factor: [ConstScaleFactor\(\)](#)

Examples

```

parm<-function(x){function() {return(x)}}
1F<-list()
1F$ScaleFactor1<-parm(0.90)
UniformRandomScaleFactor(1F)
1F$ScaleFactor1<-parm(1.10)
UniformRandomScaleFactor(1F)

```

xegaDfCrossGene	<i>One point crossover of 2 genes.</i>
-----------------	--

Description

xegaDfCrossGene() randomly determines a cut point. It combines the parameters before the cut point of the first gene with the parameters after the cut point from the second gene (kid 1).

Usage

```
xegaDfCrossGene(gg1, gg2, 1F)
```

Arguments

gg1 Real-coded gene.
 gg2 Real-coded gene.
 1F Local configuration of the genetic algorithm.

Value

Real-coded gene.

See Also

Other Crossover (Returns 1 Kid): [xegaDfUCrossGene\(\)](#), [xegaDfUPCrossGene\(\)](#)

Examples

```
gene1<-xegaDfInitGene(1FxegaDfGene)
gene2<-xegaDfInitGene(1FxegaDfGene)
gene3<-xegaDfCrossGene(gene1, gene2, 1FxegaDfGene)
```

xegaDfCrossoverFactory

Configure the crossover function of a genetic algorithm.

Description

xegaDfCrossoverFactory() implements the selection of one of the crossover functions in this package by specifying a text string. The selection fails ungracefully (produces a runtime error) if the label does not match. The functions are specified locally.

Current support:

Crossover functions with one kid:

1. "CrossGene" returns CrossGene().
2. "UCrossGene" returns UCrossGene(). Default.
3. "UPCrossGene" returns UPCrossGene().

Usage

```
xegaDfCrossoverFactory(method = "UCrossGene")
```

Arguments

method A string specifying the crossover function.

Details

All crossover operations return a 1 kid. This implies that some part of the genetic material is lost.

Value

Crossover function for genes.

See Also

Other Configuration: [1FxegaDfGene](#), [xegaDfGeneMapFactory\(\)](#), [xegaDfMutationFactory\(\)](#), [xegaDfReplicationFactor](#), [xegaDfScaleFactorFactory\(\)](#)

Examples

```
XGene<-xegaDfCrossoverFactory("UCrossGene")
gene1<-xegaDfInitGene(1FxegaDfGene)
gene2<-xegaDfInitGene(1FxegaDfGene)
XGene(gene1, gene2, 1FxegaDfGene)
```

xegaDfDecodeGene	<i>Decode a gene</i>
------------------	----------------------

Description

xegaDfDecodeGene() decodes a real gene.

Usage

```
xegaDfDecodeGene(gene, lF)
```

Arguments

gene	Real gene.
lF	Local configuration of the genetic algorithm.

Details

xegaDfDecodeGene() is the identity function.

Value

Decoded gene.

See Also

Other Decoder: [xegaDfGeneMapIdentity\(\)](#)

Examples

```
gene<-xegaDfInitGene(lFxegaDfGene)
xegaDfDecodeGene(gene, lFxegaDfGene)
```

xegaDfGene	<i>Package xegaDfGene.</i>
------------	----------------------------

Description

Genetic operations for real-coded genetic and evolutionary algorithms.

Details

For real-coded genes, the xegaDfGene package provides

- Gene initialization.
- Decoding of parameters.
- Scaling functions as a function factory for configuration.
- Mutation functions as well as a function factory for configuration.
- Crossover functions as well as a function factory for configuration.
- Replication functions as well as a function factory for configuration.

Current support: Functions for differential evolution (de). See Price et al. (2005).

Real-Coded Gene Representation

A real-coded gene is a named list:

- `$gene1`: the gene must be a vector of reals.
- `$fit`: the fitness value of the gene (for `EvalGeneDet` and `EvalGeneU`) or the mean fitness (for stochastic functions evaluated with `EvalGeneStoch`).
- `$evaluated`: has the gene been evaluated?
- `$evalFail`: has the evaluation of the gene failed?
- `$var`: the cumulative variance of the fitness of all evaluations of a gene. (For stochastic functions)
- `$sigma`: the standard deviation of the fitness of all evaluations of a gene. (For stochastic functions)
- `$obs`: the number of evaluations of a gene. (For stochastic functions)

Abstract Interface of Problem Environment

We reuse the abstract interface of a problem environment for binary-coded genes. The number of parameters is given by `length(penv$bitlength())`.

A problem environment `penv` must provide:

- `$f(parameters, gene, lF)`: Function with a real parameter vector as first argument which returns a gene with evaluated fitness.
- `$genelength()`: The number of bits of the binary coded real parameter vector. Used in `InitGene`.
- `$bitlength()`: A vector specifying the number of bits used for coding each real parameter. If `penv$bitlength()[1]` is 20, then `parameters[1]` is coded by 20 bits. Used in `GeneMap`.
- `$lb()`: The lower bound vector of each parameter. Used in `GeneMap`.
- `$ub()`: The upper bound vector of each parameter. Used in `GeneMap`.

The Architecture of the xegaX-Packages

The xegaX-packages are a family of R-packages which implement eXtended Evolutionary and Genetic Algorithms (xega). The architecture has 3 layers, namely the user interface layer, the population layer, and the gene layer:

- The user interface layer (package xega) provides a function call interface and configuration support for several algorithms: genetic algorithms (sga), permutation-based genetic algorithms (sgPerm), derivation-free algorithms as e.g. differential evolution (sgde), grammar-based genetic programming (sgp) and grammatical evolution (sge).
- The population layer (package xegaPopulation) contains population-related functionality as well as support for population statistics dependent adaptive mechanisms and parallelization.
- The gene layer is split into a representation-independent and a representation-dependent part:
 1. The representation-independent part (package xegaSelectGene) is responsible for variants of selection operators, evaluation strategies for genes, as well as profiling and timing capabilities.
 2. The representation-dependent part consists of the following packages:
 - xegaGaGene for binary coded genetic algorithms.
 - xegaPermGene for permutation-based genetic algorithms.
 - xegaDfGene for derivation-free algorithms as e.g. differential evolution.
 - xegaGpGene for grammar-based genetic algorithms.
 - xegaGeGene for grammatical evolution algorithms.

The packages xegaDerivationTrees and xegaBNF support the last two packages: xegaBNF essentially provides a grammar compiler, and xegaDerivationTrees is an abstract data type for derivation trees.

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<URL

<https://github.com/ageyerschulz/xegaDfGene>>

Installation

From CRAN by `install.packages('xegaDfGene')`

Author(s)

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References

Price, Kenneth V., Storn, Rainer M. and Lampinen, Jouni A. (2005) The Differential Evolution Algorithm (Chapter 2), pp. 37-134. In: Differential Evolution. A Practical Approach to Global Optimization. Springer, Berlin. <doi:10.1007/3-540-31306-0>

See Also

Useful links:

- <https://github.com/ageyerschulz/xegaDfGene>

xegaDfGeneMapFactory *Configure the gene map function of a genetic algorithm.*

Description

xegaDfGeneMapFactory() implements the selection of one of the GeneMap functions in this package by specifying a text string. The selection fails ungracefully (produces a runtime error) if the label does not match. The functions are specified locally.

Current support:

1. "Identity" returns GeneMapIdentity(). (Default)

Usage

```
xegaDfGeneMapFactory(method = "Identity")
```

Arguments

method	String specifying the GeneMap function.
--------	---

Value

Gene map function for genes.

See Also

Other Configuration: [lFxegaDfGene](#), [xegaDfCrossoverFactory\(\)](#), [xegaDfMutationFactory\(\)](#), [xegaDfReplicationFactory\(\)](#), [xegaDfScaleFactorFactory\(\)](#)

Examples

```
XGene<-xegaDfGeneMapFactory("Identity")
gene1<-xegaDfInitGene(lFxegaDfGene)
XGene(gene1, lFxegaDfGene$penv)
```

`xegaDfGeneMapIdentity` *Map the parameter vector of a real-coded gene to an identical vector.*

Description

`xegaDfGeneMapIdentity()` maps the real parameter vector to an identical vector.

Usage

```
xegaDfGeneMapIdentity(gene, penv)
```

Arguments

<code>gene</code>	Real-coded gene (the genotype).
<code>penv</code>	Problem environment.

Details

A *gene* is a list with

1. `$evaluated`: Boolean. TRUE if the fitness is known.
2. `$fit`: The fitness of the genotype of `$gene1`.
3. `$gene1`: A real parameter vector (the genotype).

Value

Decoded gene (the phenotype).

See Also

Other Decoder: [xegaDfDecodeGene\(\)](#)

Examples

```
gene<-xegaDfInitGene(1FxegaDfGene)
xegaDfGeneMapIdentity(gene$gene1, 1FxegaDfGene$penv)
```

xegaDfInitGene	<i>Initialize a real-coded gene.</i>
----------------	--------------------------------------

Description

xegaDfInitGene() generates a random real-coded gene with a given length.

Usage

```
xegaDfInitGene(lf)
```

Arguments

lf Local configuration of the genetic algorithm.

Details

In the real-coded representation of package xegaDf, *gene* is at least a list with

1. `$evaluated`: Boolean. TRUE if the fitness is known.
2. `$fit`: The fitness of the genotype of `$gene1`.
3. `$gene1`: a real vector (the genotype).

Value

A real-coded gene (a named list):

- `$evaluated`: FALSE. See package xegaSelectGene.
- `$evalFail`: FALSE. Set by the error handler(s) of the Evaluation Functions in package xegaSelectGene in the case of failure.
- `$fit`: Fitness.
- `$gene1`: A vector of reals.

References

Price, Kenneth V., Storn, Rainer M. and Lampinen, Jouni A. (2005) The Differential Evolution Algorithm (Chapter 2), pp. 37-134. In: Differential Evolution. A Practical Approach to Global Optimization. Springer, Berlin. <doi:10.1007/3-540-31306-0>

See Also

Other Initialization: [xegaGedeInitGene\(\)](#)

Examples

```
xegaDfInitGene(lf=xegaDfGene)
```

xegaDfMutateGeneDE	<i>Mutate a gene (differential mutation).</i>
--------------------	---

Description

xegaDfMutateGeneDE() mutates a real-coded gene. The scale factor is given by 1F\$ScaleFactor().

Usage

```
xegaDfMutateGeneDE(gene0, gene1, gene2, 1F)
```

Arguments

gene0	Real-coded gene (the base vector).
gene1	Real-coded gene.
gene2	Real-coded gene.
1F	Local configuration.

Details

The difference between gene1 and gene2 is scaled by 1F\$ScaleFactor() and added to gene0.

Value

Real-coded gene.

References

Price, Kenneth V., Storn, Rainer M. and Lampinen, Jouni A. (2005) The Differential Evolution Algorithm (Chapter 2), pp. 37-134. In: Differential Evolution. A Practical Approach to Global Optimization. Springer, Berlin. <doi:10.1007/3-540-31306-0>

Examples

```
gene0<-xegaDfInitGene(1FxegaDfGene)
gene1<-xegaDfInitGene(1FxegaDfGene)
gene2<-xegaDfInitGene(1FxegaDfGene)
gene<-xegaDfMutateGeneDE(gene0, gene1, gene2, 1FxegaDfGene)
```

xegaDfMutationFactory *Configure the mutation function of a genetic algorithm.*

Description

xegaDfMutationFactory() implements the selection of one of the mutation functions in this package by specifying a text string. The selection fails ungracefully (produces a runtime error), if the label does not match. The functions are specified locally.

Current support:

1. "MutateGene" returns xegaDfMutateGeneDE(). To provide a working default for more than one gene representation.
2. "MutateGeneDE" returns xegaDfMutateGeneDE().

Usage

```
xegaDfMutationFactory(method = "MutateGene")
```

Arguments

method	A string specifying the mutation function.
--------	--

Value

A mutation function for genes.

See Also

Other Configuration: [lFxegaDfGene](#), [xegaDfCrossoverFactory\(\)](#), [xegaDfGeneMapFactory\(\)](#), [xegaDfReplicationFactory\(\)](#), [xegaDfScaleFactorFactory\(\)](#)

Examples

```
Mutate<-xegaDfMutationFactory("MutateGene")
gene1<-xegaDfInitGene(lFxegaDfGene)
gene2<-xegaDfInitGene(lFxegaDfGene)
gene3<-xegaDfInitGene(lFxegaDfGene)
Mutate(gene1, gene2, gene3, lFxegaDfGene)
```

xegaDfReplicateGeneDE *Replicates a gene (differential evolution).*

Description

xegaDfReplicateGeneDE() replicates a gene. Replication is the reproduction function which uses crossover and mutation. The control flow of differential evolution is as follows:

- A target gene is selected from the population.
- A mutant gene is generated by differential mutation.
- The gene and the mutant gene are crossed to get a new gene.
- The gene is accepted if it is at least as good as the target gene.

Usage

```
xegaDfReplicateGeneDE(pop, fit, lF)
```

Arguments

pop	Population of real-coded genes.
fit	Fitness vector.
lF	Local configuration of the genetic algorithm.

Details

For selection="UniformP", for crossover="UPCrossGene" and for accept="Best" this is the algorithm of Price, Storn and Lampinen (2005), page 41.

Value

A list of one gene.

References

Price, Kenneth V., Storn, Rainer M. and Lampinen, Jouni A. (2005) The Differential Evolution Algorithm (Chapter 2), pp. 37-134. In: Differential Evolution. A Practical Approach to Global Optimization. Springer, Berlin. <doi:10.1007/3-540-31306-0>

Examples

```
pop10<-lapply(rep(0,10), function(x) xegaDfGene::xegaDfInitGene(lF=xegaDfGene))
epop10<-lapply(pop10, lF=xegaDfGene$EvalGene, lF=lF=xegaDfGene)
fit10<-unlist(lapply(epop10, function(x) {x$fit}))
newgenes<-xegaDfReplicateGeneDE(pop10, fit10, lF=xegaDfGene)
```

`xegaDfReplicationFactory`*Configure the replication function of a genetic algorithm.*

Description

`xegaDfReplicationFactory()` implements the selection of a replication method.

Current support:

1. "DE" returns `xegaDfReplicateGeneDE()`.

Usage

```
xegaDfReplicationFactory(method = "DE")
```

Arguments

method	A string specifying the replication function.
--------	---

Value

A replication function for genes.

See Also

Other Configuration: [lFxegaDfGene](#), [xegaDfCrossoverFactory\(\)](#), [xegaDfGeneMapFactory\(\)](#), [xegaDfMutationFactory\(\)](#), [xegaDfScaleFactorFactory\(\)](#)

Examples

```
pop10<-lapply(rep(0,10), function(x) xegaDfInitGene(lFxegaDfGene))
epop10<-lapply(pop10, lFxegaDfGene$EvalGene, lF=lFxegaDfGene)
fit10<-unlist(lapply(epop10, function(x) {x$fit}))
Replicate<-xegaDfReplicationFactory("DE")
newgenes2<-Replicate(pop10, fit10, lFxegaDfGene)
```

xegaDfScaleFactorFactory

Configure the scale factor function for differential mutation.

Description

xegaDfScaleFactorFactory() implements the selection of one of the scale factor functions in this package by specifying a text string. The selection fails ungracefully (produces a runtime error) if the label does not match. The functions are specified locally.

Current support:

1. "Const" returns ConstScaleFactor().
2. "Uniform" returns UniformRandomScaleFactor().

Usage

```
xegaDfScaleFactorFactory(method = "Const")
```

Arguments

method A string specifying the scale factor function.

Details

In the literature, several approaches have been suggested. For a review see Sharma et al. (2019).

Value

A scale factor function for genes.

References

Sharma, Prashant; Sharma, Harish; Kumar, Sandeep; Bansal, Jagdish Chand (2019): A Review on Scale Factor Strategies in Differential Evolution Algorithm. pp. 925-934. In: Bansal, Jagdish Chand et al. (2019) Soft Computing for Problem Solving. Advances in Intelligent Systems and Computing, Vol. 817. Springer, Singapore, 2019. (ISBN:978-981-13-1594-7)

See Also

Other Configuration: [lFxegaDfGene](#), [xegaDfCrossoverFactory\(\)](#), [xegaDfGeneMapFactory\(\)](#), [xegaDfMutationFactory\(\)](#), [xegaDfReplicationFactory\(\)](#)

Examples

```
f<-xegaDfScaleFactorFactory("Const")
f(lFxegaDfGene)
f<-xegaDfScaleFactorFactory("Uniform")
f(lFxegaDfGene)
f(lFxegaDfGene)
```

xegaDfUCrossGene	<i>Uniform crossover of 2 genes.</i>
------------------	--------------------------------------

Description

xegaDfUCrossGene() swaps alleles of both genes with a probability of 0.5. It generates a random mask which is used to build the new gene.

Usage

```
xegaDfUCrossGene(gg1, gg2, lF)
```

Arguments

gg1	Real-coded gene.
gg2	Real-coded gene.
lF	Local configuration of the genetic algorithm.

Value

Real-coded gene.

References

Syswerda, Gilbert (1989): Uniform Crossover in Genetic Algorithms. In: Schaffer, J. David (Ed.) Proceedings of the Third International Conference on Genetic Algorithms, Morgan Kaufmann Publishers, Los Altos, California, pp. 2-9. (ISBN:1-55860-066-3)

See Also

Other Crossover (Returns 1 Kid): [xegaDfCrossGene\(\)](#), [xegaDfUPCrossGene\(\)](#)

Examples

```
gene1<-xegaDfInitGene(lFxegaDfGene)
gene2<-xegaDfInitGene(lFxegaDfGene)
gene3<-xegaDfUCrossGene(gene1, gene2, lFxegaDfGene)
```

xegaDfUPCrossGene	<i>Parameterized uniform crossover of 2 genes.</i>
-------------------	--

Description

xegaDfUPCrossGene() swaps alleles of both genes with a probability of 1F\$UCrossSwap(). It generate a random mask which is used to build the new gene.

Usage

```
xegaDfUPCrossGene(gg1, gg2, 1F)
```

Arguments

gg1	Real-coded gene.
gg2	Real-coded gene.
1F	Local configuration of the genetic algorithm.

Value

Real-coded gene.

References

Spears William and De Jong, Kenneth (1991): On the Virtues of Parametrized Uniform Crossover. In: Belew, Richard K. and Booker, Lashon B. (Ed.) Proceedings of the Fourth International Conference on Genetic Algorithms, Morgan Kaufmann Publishers, Los Altos, California, pp. 230-236. (ISBN: 1-55860-208-9)

Price, Kenneth V., Storn, Rainer M. and Lampinen, Jouni A. (2005) The Differential Evolution Algorithm (Chapter 2), pp. 37-134. In: Differential Evolution. A Practical Approach to Global Optimization. Springer, Berlin. <doi:10.1007/3-540-31306-0>

See Also

Other Crossover (Returns 1 Kid): [xegaDfCrossGene\(\)](#), [xegaDfUCrossGene\(\)](#)

Examples

```
gene1<-xegaDfInitGene(1FxegaDfGene)
gene2<-xegaDfInitGene(1FxegaDfGene)
gene3<-xegaDfUPCrossGene(gene1, gene2, 1FxegaDfGene)
```

xegaGedeInitGene	<i>Initialize a real-coded gene for grammar evolution</i>
------------------	---

Description

xegaGedeInitGene() generates a random real-coded gene with a given length.

Usage

```
xegaGedeInitGene(lf)
```

Arguments

lf Local configuration of the genetic algorithm.

Details

In the real-coded representation of package xegaDf, *gene* is at least a list with

1. `$evaluated`: Boolean. TRUE if the fitness is known.
2. `$fit`: The fitness of the genotype of `$gene1`.
3. `$gene1`: a real vector (the genotype).

Value

A real-coded gene (a named list):

- `$evaluated`: FALSE. See package xegaSelectGene.
- `$evalFail`: FALSE. Set by the error handler(s) of the Evaluation Functions in package xegaSelectGene in the case of failure.
- `$fit`: Fitness.
- `$gene1`: A vector of reals.

References

Price, Kenneth V., Storn, Rainer M. and Lampinen, Jouni A. (2005) The Differential Evolution Algorithm (Chapter 2), pp. 37-134. In: Differential Evolution. A Practical Approach to Global Optimization. Springer, Berlin. <doi:10.1007/3-540-31306-0>

See Also

Other Initialization: [xegaDfInitGene\(\)](#)

Examples

```
xegaGedeInitGene(lfxegaDfGene)
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