

Package ‘noia’

February 20, 2015

Type Package

Title Implementation of the Natural and Orthogonal InterAction (NOIA) model

Version 0.97.1

Date 2015-01-06

Author Arnaud Le Rouzic (2007-2014), Arne B. Gjuvslund (2010), Olivier Ariste (2010)

Maintainer Arnaud Le Rouzic <lerouzic@legs.cnrs-gif.fr>

Depends stats

LazyData yes

Description The NOIA model, as described extensively in Alvarez-Castro & Carlborg (2007), is a framework facilitating the estimation of genetic effects and genotype-to-phenotype maps. This package provides the basic tools to perform linear and multilinear regressions from real populations (provided the phenotype and the genotype of every individuals), estimating the genetic effects from different reference points, the genotypic values, and the decomposition of genetic variances in a multi-locus, 2 alleles system. This package is presented in Le Rouzic & Alvarez-Castro (2008).

License GPL-2

NeedsCompilation no

Repository CRAN

Date/Publication 2015-01-08 18:21:15

R topics documented:

Genetic effects	2
Genetic regression	3
Genotype-to-Phenotype map	5
GP map analysis	6
NOIA package	8
plot.noia	10
print.noia	11
Simulate population	12
Variance decomposition	14

Genetic effects	<i>Genetic Effects</i>
-----------------	------------------------

Description

`geneticEffects` displays the genetic effects (and their standard errors) from the result of [linearRegression](#). If a new reference point is provided, a "change of reference" operation is performed (Alvarez-Castro and Carlborg 2007).

Usage

```
geneticEffects(obj, reference="P1", ref.genotype = NULL)
```

Arguments

<code>obj</code>	An object of class "noia.linear" provided by linearRegression .
<code>reference</code>	The new reference point. Can be "F2", "F1", "Finf", "P1", "P2" (see linearRegression for details).
<code>ref.genotype</code>	The same as <code>reference</code> , provided for compatibility with older versions.

Details

Variance decomposition and change of reference operation are not possible from the result of a multilinear regression.

Author(s)

Arnaud Le Rouzic <a.p.s.lerouzic@bio.uio.no>

References

Alvarez-Castro JM, Carlborg O. (2007). A unified model for functional and statistical epistasis and its application in quantitative trait loci analysis. *Genetics* 176(2):1151-1167.

Le Rouzic A, Alvarez-Castro JM. (2008). Estimation of genetic effects and genotype-phenotype maps. *Evolutionary Bioinformatics*, 4.

See Also

[linearRegression](#), [multilinearRegression](#).

Examples

```
map <- c(0.25, -0.75, -0.75, -0.75, 2.25, 2.25, -0.75, 2.25, 2.25)
pop <- simulatePop(map, N=500, sigmaE=0.2, type="F2")

# Regressions

linear <- linearRegression(phen=pop$phen, gen=cbind(pop$Loc1, pop$Loc2))

geneticEffects(linear, "P1")
```

Genetic regression *Linear and Multilinear Genetic Regressions*

Description

The regression aims at estimating genetic effects from a population in which the genotypes and phenotypes are known.

Usage

```
linearRegression(phen, gen=NULL, genZ=NULL,
  reference="noia", max.level=NULL, max.dom=NULL, fast=FALSE)
multilinearRegression(phen, gen=NULL, genZ=NULL,
  reference="noia", max.level=NULL, max.dom=NULL, fast=FALSE,
  e.unique=FALSE, start.algo = "linear", start.values=NULL,
  robust=FALSE, bilinear.steps=1, ...)
```

Arguments

phen	The vector of individual phenotypes measured in the population.
gen	The matrix of individual genotypes in the population, one column per locus. See genNames for the genotype encoding. Not necessary if genZ is provided.
genZ	The matrix of individual genotypic probabilities in the population, 3 columns per locus, corresponding of the probability of each of the 3 genotypes (the sum must be 1). Not necessary if gen is provided.
reference	The reference point from which the regression is performed. By default, the "noia" reference point is used, since it provides a fairly good orthogonality. Other possibilities are "G2A", "F2", "F1", "Finf", "UWR", "P1" and "P2".
max.level	Maximum level of interactions.
max.dom	Maximum level for dominance effects. Does not have any effect if \geq max.level. In the multilinear regression, the maximum level for dominance effects cannot be > 1 .
fast	This "fast" algorithm should be used when (i) the number of loci is high (> 8) and (ii) there are uncertainties in the dataset (missing values or Haley-Knott regression). This algorithm computes the regression matrix directly function, i.e. without computing Z nor S matrices.

<code>e.unique</code>	Whether the multilinear term is the same for all pairs.
<code>start.algo</code>	Algorithm used to compute the starting values. Can be "linear", "multilinear", "subset" or "bilinear". Ignored if <code>start.values</code> are provided.
<code>start.values</code>	Vector of starting values.
<code>robust</code>	Tries sequentially all starting values algorithms.
<code>bilinear.steps</code>	Number of steps. Ignored if <code>start.algo</code> is not "bilinear". If NULL, the bilinear algorithm is run until (almost) convergence.
<code>...</code>	Extra parameters to the non-linear regression function <code>nls</code> , including <code>nls.control</code> .

Details

If a gen data set is provided, it will be turned into a `genZ`. Missing data (unknown genotypes) are considered as loci for which genotypic probabilities are identical to the genotypic frequencies in the population.

The algebraic framework is described extensively in Alvarez-Castro & Carlborg 2007. The default reference point ("noia") provides an orthogonal decomposition of genetic effects in the 1-locus case, whatever the genotypic frequencies. It remains a good approximation of orthogonality in the multi-locus case if linkage disequilibrium is small. Other optional reference points are those of the "G2A" model (Zeng et al. 2005), and the unweighted regression model "UWR" (Cheverud & Routman, 1995). Several key populations can be taken as reference as well: "F2", "F1", "Finf" (F infinity), and the two "parental" homozygous populations "P1" and "P2".

The multilinear model for genetic interactions is an alternative way to model epistatic interactions between at least two loci (see Hansen & Wagner 2001). The computation of multilinear estimates requires a non-linear regression step that relies on the `nls` function. Providing good starting values for the non-linear regression is a key to ensure convergence, and different algorithms are provided, that can be specified by the "start.algo" option. "linear" performs a linear regression and approximates the genetic effects from it, while "multilinear" performs a simpler multilinear regression (without dominance) to initialize the genetic effects. "subset" estimate all genetic effects from a random subset (50%) of the population, and "bilinear" estimate alternatively marginal and epistatic effects.

Value

`linearRegression` and `multilinearRegression` return an object of class "noia.linear" or "noia.multilinear", both having their own `print` methods: `print.noia.linear` and `print.noia.multilinear`.

Author(s)

Arnaud Le Rouzic <a.p.s.lerouzic@bio.uio.no>

References

- Alvarez-Castro JM, Carlborg O. (2007). A unified model for functional and statistical epistasis and its application in quantitative trait loci analysis. *Genetics* 176(2):1151-1167.
- Alvarez-Castro JM, Le Rouzic A, Carlborg O. (2008). How to perform meaningful estimates of genetic effects. *PLoS Genetics* 4(5):e1000062.

Cheverud JM, Routman, EJ. (1995). Epistasis and its contribution to genetic variance components. *Genetics* 139:1455-1461.

Hansen TF, Wagner G. (2001) Modeling genetic architecture: A multilinear theory of gene interactions. *Theoretical Population Biology* 59:61-86.

Le Rouzic A, Alvarez-Castro JM. (2008). Estimation of genetic effects and genotype-phenotype maps. *Evolutionary Bioinformatics* 4.

Zeng ZB, Wang T, Zou W. (2005). Modelling quantitative trait loci and interpretation of models. *Genetics* 169: 1711-1725.

See Also

[geneticEffects](#), [GPmap](#), [varianceDecomposition](#).

Examples

```
set.seed(123456789)

map <- c(0.25, -0.75, -0.75, -0.75, 2.25, 2.25, -0.75, 2.25, 2.25)
pop <- simulatePop(map, N=500, sigmaE=0.2, type="F2")

# Regressions

linear <- linearRegression(phen=pop$phen, gen=cbind(pop$Loc1, pop$Loc2))

multilinear <- multilinearRegression(phen=pop$phen,
  gen=cbind(pop$Loc1, pop$Loc2))

# Linear effects, associated variances and stderr
linear

# Multilinear effects
multilinear
```

Genotype-to-Phenotype map

Genotype-to-Phenotype Mapping

Description

The Genotype-to-Phenotype map is a vector providing the estimate of the genotypic value for any multi-locus genotype. The estimates may be computed from [linearRegression](#) or [multilinearRegression](#).

Usage

```
GPmap(obj)
```

Arguments

obj An object of class "noia.linear" or "noia.multilinear".

Value

Returns a matrix with two columns: the first one is the estimate of genotypic effects, the second one the standard error of this estimate.

Author(s)

Arnaud Le Rouzic <a.p.s.lerouzic@bio.uio.no>

References

Le Rouzic A, Alvarez-Castro JM. (2008). Estimation of genetic effects and genotype-phenotype maps. *Evolutionary Bioinformatics*, 4.

See Also

[linearRegression](#), [multilinearRegression](#), [genNames](#).

Examples

```
set.seed(123456789)

map <- c(0.25, -0.75, -0.75, -0.75, 2.25, 2.25, -0.75, 2.25, 2.25)
pop <- simulatePop(map, N=500, sigmaE=0.2, type="F2")

# Regression
linear <- linearRegression(phen=pop$phen, gen=cbind(pop$Loc1, pop$Loc2))

# GP map
GPmap(linear)
```

GP map analysis	<i>Noia analysis of genotype-to-phenotype (GP) maps in ideal populations</i>
-----------------	--

Description

Functions for doing a NOIA analysis of a GP map for L loci in a population where the loci are in complete linkage equilibrium.

Usage

```
linearGPmapanalysis(gmap, reference="F2", freqmat=NULL,
                    max.level=NULL, S_full=NULL)
```

Arguments

gmap	Vector of length 3^L with genotypic values for all possible genotypes in the order defined by genNames .
reference	The reference population in which the analysis is done. By default, the "F2" population is used. Other possibilities are "noia", "G2A", "UWR".
freqmat	For reference="G2A": A vector of length L containing allele frequencies such that <code>freqmat[i]=frequency(allele 1)</code> for locus i . For reference="noia": A $(L \times 3)$ matrix of genotype frequencies such that <code>freqmat[i,]=[frequency(1) frequency(2) frequency(3)]</code> for locus i .
max.level	Maximum level of interactions.
S_full	Boolean argument indicating whether to keep full S matrix ($3^L \times 3^L$) in memory or alternatively to keep L single locus S matrices (3×3) and compute single row and columns of the full matrix.

Details

The algebraic framework is described extensively in Alvarez-Castro & Carlborg 2007. When analysing GP maps in ideal populations we can work directly with the S matrix and do not have to consider the X and Z matrices used in [linearRegression](#). When it comes to the `S_full` argument keeping the multilocus S matrix in memory is generally fastest for computing all 3^L genetic effects. However it does not allow for computing only a subset of the effects and also runs out of memory for $L > 8$ on a typical desktop machine. For `S_full=NULL` in `linearGPmapanalysis` a full S matrix is used if $L \leq 8$ and `max.level=NULL`, while L single locus S matrices are used otherwise.

Value

`linearGPmapanalysis` returns an object of class "noia.linear.gpmap", with its own `print` method: `print.noia.linear.gpmap`.

Author(s)

Arne B. Gjuvsland <arne.gjuvsland@umb.no>

References

- Alvarez-Castro JM, Carlborg O. (2007). A unified model for functional and statistical epistasis and its application in quantitative trait loci analysis. *Genetics* 176(2):1151-1167.
- Cheverud JM, Routman, EJ. (1995). Epistasis and its contribution to genetic variance components. *Genetics* 139:1455-1461.
- Le Rouzic A, Alvarez-Castro JM. (2008). Estimation of genetic effects and genotype-phenotype maps. *Evolutionary Bioinformatics* 4.
- Zeng ZB, Wang T, Zou W. (2005). Modelling quantitative trait loci and interpretation of models. *Genetics* 169: 1711-1725.

See Also

[varianceDecomposition](#)

Examples

```
map <- c(0.25, -0.75, -0.75, -0.75, 2.25, 2.25, -0.75, 2.25, 2.25)

# Genotype-to-phenotype map analysis
linearGP <- linearGMapanalysis(map, reference="F2")

# Linear effects in ideal F2 population
linearGP
```

NOIA package

Implementation of the Natural and Orthogonal InterAction (NOIA) model

Description

The NOIA model, as described extensively in Alvarez-Castro & Carlborg (2007), is a framework facilitating the estimation of geneticEffects and genotype-to-phenotype maps. This package provides the basic tools to perform linear and multilinear regressions from real populations, analyse pure genotype-to-phenotype (GP) maps in ideal populations, estimating the genetic effects from different reference points, the genotypic values, and the decomposition of genetic variances in a multi-locus, 2 alleles system. This package is extensively described in Le Rouzic & Alvarez-Castro (2008).

Details

Package: noia
 Type: Package
 Version: 0.94.1
 Date: 2010-04-20
 License: GPL-2

Regression data set: The user must provide (i) The vector of phenotypes of all individuals measured in the population, and (ii) The matrix of the genotypes. There are two input formats for the genotype, see [linearRegression](#).

Regression functions: [linearRegression](#) and [multilinearRegression](#).

GP map data set: The user must provide (i) The 3^L (where L is the number of loci) vector of genotypic values (\mathbf{G} in Alvarez-Castro & Carlborg (2007)) (ii) Allele or genotype frequencies in the reference population.

GP map analysis function: [linearGMapanalysis](#).

Change of reference: [geneticEffects](#).

Genotype-to-phenotype map: [GPmap](#).

Decomposition of genetic variance: [varianceDecomposition](#).

Author(s)

Arnaud Le Rouzic, Arne B. Gjuvsland

Maintainer: Arnaud Le Rouzic <a.p.s.lerouzic@bio.uio.no>, , Arne B. Gjuvsland <arne.gjuvsland@umb.no>

References

Alvarez-Castro JM, Carlborg O. (2007). A unified model for functional and statistical epistasis and its application in quantitative trait loci analysis. *Genetics* 176(2):1151-1167.

Alvarez-Castro JM, Le Rouzic A, Carlborg O. (2008). How to perform meaningful estimates of genetic effects. *PLoS Genetics* 4(5):e1000062.

Le Rouzic A, Alvarez-Castro JM. (2008). Estimation of genetic effects and genotype-phenotype maps. *Evolutionary Bioinformatics* 4.

Examples

```
set.seed(123456789)

map <- c(0.25, -0.75, -0.75, -0.75, 2.25, 2.25, -0.75, 2.25, 2.25)
names(map) <- genNames(2)
pop <- simulatePop(map, N=500, sigmaE=0.2, type="F2")

# Regressions

linear <- linearRegression(phen=pop$phen, gen=pop[2:3])

multilinear <- multilinearRegression(phen=pop$phen, gen=cbind(pop$Loc1,
pop$Loc2))

# Linear effects, associated variances and stderr
linear

# Multilinear effects
multilinear

# Genotype-to-phenotype map analysis
linearGP <- linearGPmapanalysis(map, reference="F2")

# Linear effects in ideal F2 population
linearGP

# Change of reference: geneticEffects in the "11" genotype (parental 1)
geneticEffects(linear, ref.genotype="P1")

# Variance decomposition
varianceDecomposition(linear)
```

```

varianceDecomposition(linearGP)

# GP maps
maps <- cbind(map, GPmap(linear)[,1], GPmap(multilinear)[,1])
colnames(maps) <- c("Actual", "Linear", "Multilinear")
maps

```

plot.noia *Graphical display of genetic regressions and genotype-phenotype maps*

Description

These functions allow a graphic representation of the result of genetic regressions from [linearRegression](#) and [GPmap](#).

Usage

```

## S3 method for class 'noia.linear'
plot(x, loc = 1:x$nloc, effect=TRUE, epistasis = TRUE,
     ylim=range(GPmap(x)[,1]) + c(-1,1)*max(GPmap(x)[,2]), ...)
## S3 method for class 'noia.gpmap'
barplot(height, GPcol = c("indianred", "palegreen", "royalblue"),
        arrowscol = "purple", stderr = TRUE , main=NA, ylab=NA, ...)

```

Arguments

x	An object of class "noia.linear" for the plot function, or of class "noia.gpmap" for the barplot function.
loc	The vector loci to plot (by default, all of them are displayed).
effect	Whether genetic effects have to be plotted for each locus.
epistasis	Whether pairwise effects have to be plotted.
height	An object of class "noia.gpmap".
GPcol	Colors for each of the three genotypes.
arrowscol	Color of the error bars.
stderr	If TRUE, error bars stand for standard errors. Otherwise, error bars are 95% confidence intervals.
main	The same as in plot .
ylab	The same as in plot .
ylim	The same as in plot .
...	Additional options for the plot and barplot routines.

Author(s)

Olivier Ariste, Arnaud Le Rouzic <lerouzic@legs.cnrs-gif.fr>

print.noia

Printing Genetic Regressions and GP map analyses

Description

Display the output of functions [linearRegression](#), [multilinearRegression](#) and [linearGPmapanalysis](#)

Usage

```
## S3 method for class 'noia.linear'  
print(x, ...)  
## S3 method for class 'noia.multilinear'  
print(x, ...)  
## S3 method for class 'noia.common'  
print(x, ...)  
## S3 method for class 'noia.linear.gpmap'  
print(x, ...)
```

Arguments

x	An object of class "noia.linear", class "noia.linear.gpmap" or class "noia.multilinear".
...	No effect for the moment.

Details

The print method being actually very similar for the linear and multilinear regressions, both call the common method `print.noia.common`.

Author(s)

Arnaud Le Rouzic <a.p.s.lerouzic@bio.uio.no>, Arne B. Gjuvsland <arne.gjuvsland@umb.no>

References

Le Rouzic A, Alvarez-Castro JM. (2008). Estimation of genetic effects and genotype-phenotype maps. *Evolutionary Bioinformatics*, 4.

Simulate population *Simulates a Population from a Genotype-Phenotype Map*

Description

The `simulatePop` function takes a Genotype-to-Phenotype map (i.e. a vector defining the genotypic value of all possible genotypes) and returns a data frame containing the simulated population.

Usage

```
simulatePop(gmap, N = 100, sigmaE = 1, type = "F2", freqmat=NULL)
```

Arguments

<code>gmap</code>	The Genotype-to-phenotype map: a vector of size 3^L , where L is the number of loci. The vector should be named with the code of each genotype (see genNames).
<code>N</code>	Number of individuals.
<code>sigmaE</code>	Standard deviation of the environmental noise (normally distributed).
<code>type</code>	Type of population. "F2", "Finf", "F1", "UWR", "G2A", and "noia" are possible.
<code>freqmat</code>	For type="G2A": A vector of length <code>nloc</code> containing allele frequencies such that <code>freqmat[i]=frequency(allele 1)</code> for locus <code>i</code> . For type="noia": A (<code>nloc</code> x 3) matrix of genotype frequencies such that <code>freqmat[i,]=[frequency(1) frequency(2) frequency(3)]</code> for locus <code>i</code> .

Details

The type of population refers to the expected allelic and genotypic frequencies:

- "F1" First generation of an intercross between two parental populations fixed for alleles A and B respectively; expected genotypic frequencies are: AA: 0, AB: 1, BB: 0.
- "F2" Second generation of an intercross between two parental populations fixed for alleles A and B respectively; expected genotypic frequencies are AA: 0.25, AB: 0.5, BB: 0.25.
- "Finf" Theoretical population from an infinite number of generations after an intercross between two parental populations fixed for alleles A and B respectively; expected genotypic frequencies are AA: 0.5, AB: 0, BB: 0.5.
- "UWR" Theoretical population corresponding to ideal (but experimentally unrealistic) equal genotypic frequencies; expected genotypic frequencies are AA: 0.333, AB: 0.333, BB: 0.333. In such a population, the "UnWeighted Regression model" (UWR) by Cheverud & Routman 1995 provides orthogonal estimates.
- "G2A" Population at Hardy-Weinberg frequencies; expected genotypic frequencies are: AA: p^2 , AB: $2p(1-p)$, BB: $(1-p)^2$, the frequency of allele A (p) at locus `i` being provided by the `i`-th element of vector `freqmat`. "G2A" is the name of the statistical model by Zeng et al. (2005) in which genetic effects estimated from such a population are orthogonal.

- "noia" Population in which genotypic frequencies are arbitrary; expected genotypic frequencies are: AA: pAA, AB: pAB, BB: pBB, frequencies pAA, pAB, and pBB at locus i being provided by the i-th line of matrix freqmat. "noia" is the name of the statistical model by Alvarez-Castro and Carlborg (2007) in which genetic effects estimated from such a population are orthogonal. In all populations, loci are considered as independent and are at linkage equilibrium.

Value

Returns a data frame, in which the first column (`$phen`) contains the phenotypes, and the following ones (`$Loc1`, `$Loc2`, etc) the genotypes of all individuals.

Author(s)

Arnaud Le Rouzic <a.p.s.lerouzic@bio.uio.no>, Arne B. Gjuvsland <arne.gjuvsland@umb.no>

References

Alvarez-Castro JM, Carlborg O. (2007). A unified model for functional and statistical epistasis and its application in quantitative trait loci analysis. *Genetics* 176(2):1151-1167.

Cheverud JM, Routman, EJ. (1995). Epistasis and its contribution to genetic variance components. *Genetics* 139:1455-1461.

Le Rouzic A, Alvarez-Castro JM. (2008). Estimation of genetic effects and genotype-phenotype maps. *Evolutionary Bioinformatics*, 4.

Zeng ZB, Wang T, Zou W. (2005). Modelling quantitative trait loci and interpretation of models. *Genetics* 169: 1711-1725.

See Also

[GPmap](#), [genNames](#)

Examples

```
set.seed(123456789)

map <- c(0.25, -0.75, -0.75, -0.75, 2.25, 2.25, -0.75, 2.25, 2.25)
pop <- simulatePop(map, N=500, sigmaE=0.2, type="F2")
str(pop)

## Create a "noia" population with genotype frequencies 1/3,1/3,1/3 for locus 1
## and 0.2,0.6,0.2 for locus 2
pop = simulatePop(map, N=1000, sigma=1, type='noia',
  freqmat=matrix(c(1/3,1/3,1/3,0.2,0.6,0.2),nrow=2, byrow=TRUE))
```

 Variance decomposition

Decomposition of Genetic Variance

Description

Variance decomposition is a classical operation in quantitative genetics (e.g. Fisher 1918, Lynch and Walsh 1998). The genetic variance, i.e. the part of phenotypic variance that can be identified as due to genetic factors, can be decomposed into several orthogonal components (generally, the part due to additive factors $\text{Var}(A)$, to dominance factors $\text{Var}(D)$, and to genetic interactions $\text{Var}(I)$).

Usage

```
varianceDecomposition(obj)
## S3 method for class 'noia.vardec'
print(x, ...)
```

Arguments

obj	An object of class "noia.linear", the output of linearRegression or of class "noia.linear.gpmap", the output of linearGPmapanalysis .
x	An object of class "noia.vardec", the output of varianceDecomposition .
...	No effect for the moment.

Details

The details of the variance decomposition are provided for all levels of interaction: $\text{Var}(A)$ and $\text{Var}(D)$ for marginal effects, $\text{Var}(AA)$, $\text{Var}(AD)$ and $\text{Var}(DD)$ for 2nd order interactions, etc.

Value

`varianceDecomposition` returns a list of vectors. Each element of the list corresponds to an order of interactions, and the vectors detail the variance decomposition within each level. `print.noia.vardec` prints the previous list in a nice way, and computed the percentage of genetic variance explained by each variance component.

Author(s)

Arnaud Le Rouzic <a.p.s.lerouzic@bio.uio.no>

References

Alvarez-Castro JM, Carlborg O. (2007). A unified model for functional and statistical epistasis and its application in quantitative trait loci analysis. *Genetics* 176(2):1151-1167.

Fisher RA. (1918). The correlation between relatives on the supposition of Mendelian inheritance. *Trans. Roy. Soc. Edinburgh* 52:339-433.

Le Rouzic A, Alvarez-Castro JM. (2008). Estimation of genetic effects and genotype-phenotype maps. *Evolutionary Bioinformatics*, 4.

Lynch M, Walsh B (1998) *Genetics and Analysis of Quantitative Traits*. Sunderland, MA; Sinauer Associates.

See Also

[linearRegression](#)

Examples

```
map <- c(0.25, -0.75, -0.75, -0.75, 2.25, 2.25, -0.75, 2.25, 2.25)
pop <- simulatePop(map, N=500, sigmaE=0.2, type="F2")

# Regression

linear <- linearRegression(phen=pop$phen, gen=cbind(pop$Loc1, pop$Loc2))

# Variance decomposition
varianceDecomposition(linear)
```

Index

- *Topic **datagen**
 - Simulate population, 12
- *Topic **models**
 - Genetic regression, 3
 - GP map analysis, 6
 - NOIA package, 8
 - Variance decomposition, 14
- *Topic **nonlinear**
 - Genetic regression, 3
 - GP map analysis, 6
- *Topic **package**
 - NOIA package, 8
- *Topic **plot**
 - plot.noia, 10
- *Topic **print**
 - print.noia, 11
- *Topic **regression**
 - Genetic effects, 2
 - Genetic regression, 3
 - Genotype-to-Phenotype map, 5
 - GP map analysis, 6
 - Variance decomposition, 14
- barplot, 10
- barplot.noia.gpmap (plot.noia), 10
- effectsNames (Genetic effects), 2
- Genetic effects, 2
- Genetic regression, 3
- geneticEffects, 5, 9
- geneticEffects (Genetic effects), 2
- genNames, 3, 6, 7, 12, 13
- Genotype-to-Phenotype map, 5
- GP map analysis, 6
- GPmap, 5, 9, 10, 13
- GPmap (Genotype-to-Phenotype map), 5
- linearGPmapanalysis, 8, 11, 14
- linearGPmapanalysis (GP map analysis), 6
- linearRegression, 2, 5–8, 10, 11, 14, 15
- linearRegression (Genetic regression), 3
- multilinearRegression, 2, 5, 6, 8, 11
- multilinearRegression (Genetic regression), 3
- nls, 4
- nls.control, 4
- noia (NOIA package), 8
- NOIA package, 8
- noia-package (NOIA package), 8
- plot, 10
- plot.noia, 10
- plot.noia.linear (plot.noia), 10
- print, 4, 7
- print.noia, 11
- print.noia.linear, 4
- print.noia.linear.gpmap, 7
- print.noia.multilinear, 4
- print.noia.vardec (Variance decomposition), 14
- Simulate population, 12
- simulatePop (Simulate population), 12
- Variance decomposition, 14
- varianceDecomposition, 5, 8, 9, 14
- varianceDecomposition (Variance decomposition), 14