

Package ‘qvalue’

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Title Q-value estimation for false discovery rate control

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Description This package takes a list of p-values resulting from the simultaneous testing of many hypotheses and estimates their q-values. The q-value of a test measures the proportion of false positives incurred (called the false discovery rate) when that particular test is called significant. Various plots are automatically generated, allowing one to make sensible significance cut-offs. Several mathematical results have recently been shown on the conservative accuracy of the estimated q-values from this software. The software can be applied to problems in genomics, brain imaging, astrophysics, and data mining.

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hedenfalk

Gene expression dataset from Hedenfalk et al. (2001)

Description

The data come from the breast cancer cDNA microarray experiment of Hedenfalk et al. (2001). In the original experiment, comparison was made between 3,226 genes of two mutation types, BRCA1 (7 arrays) and BRCA2 (8 arrays). The data included here are p-values obtained from a two- sample t-test analysis on a subset of 3,170 genes, as described in Storey and Tibshirani (2003).

Usage

```
data(hedenfalk)
```

Value

```
hedenfalk      Vector of 3,170 p-values of tests comparing BRCA1 to BRCA2.
```

References

Hedenfalk I et al. (2001). Gene expression profiles in hereditary breast cancer. *New Engl. Jour. Medicine*, 344: 539-548.

Storey JD and Tibshirani R. (2003). Statistical significance for genome-wide studies. *Proceedings of the National Academy of Sciences*, 100: 9440-9445.

qplot*Graphical display of qvalue objects*

Description

Graphical display of qvalue objects

Usage

```
qplot(qobj, rng = c(0, 0.1), smooth.df = 3, smooth.log.pi0 = FALSE, ...)  
## S3 method for class 'qvalue':  
plot(x, ...)
```

Arguments

<code>qobj, x</code>	Qvalue object.
<code>rng</code>	Range of q-values to consider. Optional.
<code>smooth.df</code>	Number of degrees-of-freedom to use when estimating π_0 with a smoother. Optional.
<code>smooth.log.pi0</code>	If TRUE and <code>pi0.method = "smoother"</code> , π_0 will be estimated by applying a smoother to a scatterplot of $\log \pi_0$ estimates against the tuning parameter λ . Optional.
<code>...</code>	Any other arguments.

Details

The function `qplot` allows one to view several plots:

1. The estimated π_0 versus the tuning parameter λ .
2. The q-values versus the p-values
3. The number of significant tests versus each q-value cutoff
4. The number of expected false positives versus the number of significant tests

This function makes four plots. The first is a plot of the estimate of π_0 versus its tuning parameter λ . In most cases, as λ gets larger, the bias of the estimate decreases, yet the variance increases. Various methods exist for balancing this bias-variance trade-off (Storey 2002, Storey & Tibshirani 2003, Storey, Taylor & Siegmund 2004). Comparing your estimate of π_0 to this plot allows one to gauge its quality. The remaining three plots show how many tests are significant, as well as how many false positives to expect for each q-value cut-off. A thorough discussion of these plots can be found in Storey & Tibshirani (2003).

Value

Nothing of interest.

Author(s)

John D. Storey (jstorey@u.washington.edu)

References

- Storey JD. (2002) A direct approach to false discovery rates. *Journal of the Royal Statistical Society, Series B*, 64: 479-498.
- Storey JD and Tibshirani R. (2003) Statistical significance for genome-wide experiments. *Proceedings of the National Academy of Sciences*, 100: 9440-9445.
- Storey JD. (2003) The positive false discovery rate: A Bayesian interpretation and the q-value. *Annals of Statistics*, 31: 2013-2035.
- Storey JD, Taylor JE, and Siegmund D. (2004) Strong control, conservative point estimation, and simultaneous conservative consistency of false discovery rates: A unified approach. *Journal of the Royal Statistical Society, Series B*, 66: 187-205.

QVALUE Manual <http://faculty.washington.edu/~jstorey/qvalue/manual.pdf>

See Also

[qvalue](#), [qwrite](#), [qsummary](#), [qvalue.gui](#)

Examples

```
## Not run:
p <- scan(pvalues.txt)
qobj <- qvalue(p)
qplot(qobj)
qwrite(qobj, filename=myresults.txt)

# view plots for q-values between 0 and 0.3:
plot(qobj, rng=c(0.0, 0.3))
## End(Not run)
```

qsummary

Display qvalue object

Description

Display summary information for a qvalue object.

Usage

```
qsummary(qobj, cuts = c(1e-04, 0.001, 0.01, 0.025, 0.05, 0.1, 1),
         digits = getOption("digits"), ...)
## S3 method for class 'qvalue':
summary(object, ...)
```

Arguments

qobj, object	Qvalue object
cuts	Vector of significance value to use for table (optional)
digits	Significant digits to display (optional)
...	Any other arguments

Details

qsummary shows the original call, estimated proportion of true null hypotheses, and a table comparing the number of significant calls for the raw p-values and for the calculated q-values using a set of cutoffs given by cuts.

Value

Invisibly returns the original object.

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See Also

[qvalue](#), [qplot](#), [qwrite](#), [qvalue.gui](#)

Examples

```
## Not run:
qobj <- qvalue(p)
print(qobj)
summary(qobj, cuts=c(0.01, 0.05))
## End(Not run)
```

qvalue

Estimate the q-values for a given set of p-values

Description

Estimate the q-values for a given set of p-values. The q-value of a test measures the proportion of false positives incurred (called the false discovery rate) when that particular test is called significant.

Usage

```
qvalue(p=NULL, lambda=seq(0,0.90,0.05), pi0.method="smoother", fdr.level=NULL, robust=
  smooth.df=3, smooth.log.pi0=FALSE)
```

Arguments

p	A vector of p-values (only necessary input)
lambda	The value of the tuning parameter to estimate π_0 . Must be in [0,1). Optional, see Storey (2002).
pi0.method	Either "smoother" or "bootstrap"; the method for automatically choosing tuning parameter in the estimation of π_0 , the proportion of true null hypotheses
fdr.level	A level at which to control the FDR. Must be in (0,1]. Optional; if this is selected, a vector of TRUE and FALSE is returned that specifies whether each q-value is less than fdr.level or not.
robust	An indicator of whether it is desired to make the estimate more robust for small p-values and a direct finite sample estimate of pFDR. Optional.
gui	A flag to indicate to 'qvalue' that it should communicate with the gui. Should not be specified on command line. Optional.

<code>smooth.df</code>	Number of degrees-of-freedom to use when estimating π_0 with a smoother. Optional.
<code>smooth.log.pi0</code>	If TRUE and <code>pi0.method = "smoother"</code> , π_0 will be estimated by applying a smoother to a scatterplot of $\log \pi_0$ estimates against the tuning parameter λ . Optional.

Details

If no options are selected, then the method used to estimate π_0 is the smoother method described in Storey and Tibshirani (2003). The bootstrap method is described in Storey, Taylor & Siegmund (2004).

Value

A list containing:

<code>call</code>	function call
<code>pi0</code>	an estimate of the proportion of null p-values
<code>qvalues</code>	a vector of the estimated q-values (the main quantity of interest)
<code>pvalues</code>	a vector of the original p-values
<code>significant</code>	if <code>fdr.level</code> is specified, and indicator of whether the q-value fell below <code>fdr.level</code> (taking all such q-values to be significant controls FDR at level <code>fdr.level</code>)

Author(s)

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References

Storey JD. (2002) A direct approach to false discovery rates. *Journal of the Royal Statistical Society, Series B*, 64: 479-498.

Storey JD and Tibshirani R. (2003) Statistical significance for genome-wide experiments. *Proceedings of the National Academy of Sciences*, 100: 9440-9445.

Storey JD. (2003) The positive false discovery rate: A Bayesian interpretation and the q-value. *Annals of Statistics*, 31: 2013-2035.

Storey JD, Taylor JE, and Siegmund D. (2004) Strong control, conservative point estimation, and simultaneous conservative consistency of false discovery rates: A unified approach. *Journal of the Royal Statistical Society, Series B*, 66: 187-205.

QVALUE Manual <http://faculty.washington.edu/~jstorey/qvalue/manual.pdf>

See Also

[qplot](#), [qwrite](#), [qsummary](#), [qvalue.gui](#)

Examples

```
## Not run:
p <- scan("pvalues.txt")
qobj <- qvalue(p)
qplot(qobj)
qwrite(qobj, filename="myresults.txt")

qobj <- qvalue(p, lambda=0.5, robust=TRUE)
qobj <- qvalue(p, fdr.level=0.05, pi0.method="bootstrap")
## End(Not run)
```

qvalue.gui

A graphical user interface for QValue

Description

A graphical user interface for QValue

Usage

```
qvalue.gui(dummy = NULL)
```

Arguments

dummy Dummy argument to facilitate documentation (no arguments required)

Details

This is a point-and-click version of qvalue. See the manual at <http://faculty.washington.edu/~jstorey/qvalue/manual.pdf> for documentation.

Value

Nothing of interest.

Author(s)

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See Also

[qvalue](#), [qplot](#), [qwrite](#), [qsummary](#)

Examples

```
## Not run:
qvalue.gui()
## End(Not run)
```

qwrite

Write the results of the q-value object qobj to a file

Description

Write the results of the q-value object qobj to a file.

Usage

```
qwrite(qobj, filename = "my-qvalue-results.txt")
```

Arguments

qobj	Qvalue object
filename	Output filename (optional)

Details

The output file lists the estimate of π_0 , which is the proportion of true null hypotheses. It also lists each p-value and corresponding q-value, one per line. If an FDR significance level was specified in the call to `qvalue`, the significance level is printed below the estimate of π_0 , and an indicator of significance is included as a third column for each p-value and q-value.

Value

Nothing of interest.

Author(s)

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See Also

[qvalue](#), [qplot](#), [qsummary](#), [qvalue.gui](#)

Examples

```
## Not run:  
p <- scan("pvalues.txt")  
qobj <- qvalue(p)  
qplot(qobj)  
qwrite(qobj, filename="myresults.txt")  
## End(Not run)
```

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