Package ‘ECFsup’

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Type Package

Title Equal Covariance Functions Testing by L2-Norm and Sup-Norm

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Description Testing the equality of several covariance functions of functional data. Four different methods are implemented: L2-norm with W-S naive, L2-norm with W-S bias-reduced, L2-norm (Zhang 2013) <ISBN:9781439862735>, and sup-norm with resampling (Guo et al. 2017) <arXiv:1609.04232>.

URL https://arxiv.org/abs/1609.04232

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Imports Rcpp (>= 0.12.9), foreach (>= 1.4.3)

LinkingTo Rcpp, RcppArmadillo

RoxygenNote 6.0.1

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Description

Testing the equality of several covariance functions of functional data. Four different methods are implemented: L2-norm with W-S naive, L2-norm with W-S bias-reduced, L2-norm (Zhang 2013) <ISBN:9781439862735>, and sup-norm with resampling (Guo et al. 2017) <arXiv:1609.04232>.

Details

The DESCRIPTION file:

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```

Testing equality of several covariance functions of functional data. Four different methods are implemented: L2-norm using W-S naive method, L2-norm using W-S bias-reduced method, L2-norm (ZHANG 2013, GUO et al. 2016), and sup-norm using resampling method (GUO et al. 2017). The input functional data should have been registered and presmoothed. See Ramsay and Silverman

(2005) Ch.7 for registration, Zhang (2013) Ch.3 for presmoothing. Tools for preprocessing raw functional data are available in R package **fda**, see also Ramsay et al. (2009).

Author(s)

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References

[GUO et al. (2016)], Guo, J., Zhou, B., Zhang, J.-T. (2016). A further study of an L2-norm based test for the equality of several covariance functions. https://arxiv.org/abs/1609.04231

[GUO et al. (2017)], Guo, J., Zhou, B., Zhang, J.-T. (2017). Testing the equality of several covariance functions for functional data: a supremum-norm based test. https://arxiv.org/abs/1609.04232

[PAPARODITIS and SAPATINAS (2016)], Paparoditis, E., Sapatinas, T. (2016). Bootstrap-based testing of equality of mean functions or equality of covariance operators for functional data. *Biometrika*, **103**, 727–733. doi: 10.1093/biomet/asw033

[RAMSAY and SILVERMAN (2005)], Ramsay, J. O., Silverman, B. W. (2005). *Functional Data Analysis*. Springer. doi: 10.1007/b98888

[RAMSAY et al. (2009)], Ramsay, J. O., Hooker, G., Graves, S. (2009). *Functional data analysis with R and MATLAB*. Springer. doi: 10.1007/9780387981857

[ZHANG (2013)], Zhang, J.-T. (2013). *Analysis of variance for functional data*. CRC Press.

Examples

```
fdata<-list();
fdata[[1]]<-matrix(rnorm(200),20,10);
fdata[[1]]<-matrix(rnorm(300),20,15);
KSCovL2(fdata);KSCovsup(fdata);
```

KSCovL2 *L2-norm based test of equality of several covariance functions*

Description

L2-norm test of equality of several covariance functions, using resampling to approximate the null distribution.

Usage

```
KSCovL2(data, Nsim = 1000)
```

Arguments

`data`	The list variable containing k groups of presmoothed functional observations. Each element of the list is a p (number sampling points) by n (sample size) matrix.
`Nsim`	Number of pseudo samples by resampling, default=1000.

Details

L2-norm test of equality of several covariance functions, see Zhang (2013), Guo et al. (2016).

Value

The p-value of the test.

References

ZHANG (2013), GUO et al. (2016), PAPARODITIS and SAPATINAS (2016).

See Also

`KSCovL2WS`, `KSCovsup`.

Examples

```
fdata<-list();
fdata[[1]]<-matrix(rnorm(200),20,10);
fdata[[1]]<-matrix(rnorm(300),20,15);
KSCovL2(fdata)
KSCovL2(fdata, 500)
```

`KSCovL2WS` *L2-norm test using W-S approximation for equality of several covariance functions*

Description

L2-norm test of equality of several covariance functions, using the naive or bias-reduced method (Welch–Satterthwaite approximation) to approximate the null distribution.

Usage

```
KSCovL2WS(data, apprflag = 0, method = 1, Nsim = 1000)
```

Arguments

`data`	The list variable containing k groups of presmoothed functional observations. Each element of the list is a p (number sampling points) by n (sample size) matrix.
`apprflag`	Approximation method, 0: naive method, 1: bias-reduced method.
`method`	placeholder for L2 resampling method, for testing purpose, should not use currently.
`Nsim`	placeholder for L2 resampling method, for testing purpose, should not use currently.

Details

L2-norm test of equality of several covariance functions. The null distribution will be approximated by a scaled chi-squared random variable. Two approximation methods are implemented: naive method and bias-reduced method, which work for Gaussian data only. The bias-reduced method is more accurate than the naive method for Gaussian data. The input functional data should have been registered and presmoothed. See Ramsay and Silverman (2005) Ch.7 for registration, and Zhang (2013) Ch.3 for presmoothing. Tools for preprocessing raw functional data are available in R package **fda**, see also Ramsay et al. (2009).

Value

The p-value of the test.

References

ZHANG (2013), GUO et al. (2016), RAMSAY and SILVERMAN (2005), RAMSAY et al. (2009).

See Also

`KSCovL2`, `KSCovsup`.

Examples

```
fdata<-list();
fdata[[1]]<-matrix(rnorm(200),20,10);
fdata[[1]]<-matrix(rnorm(300),20,15);
KSCovL2WS(fdata, 0)
KSCovL2WS(fdata, 1)
```

KSCovsup *Sup-norm based test of equality of several covariance functions*

Description

Sup-norm test of equality of several covariance functions, using resampling to approximate the null distribution.

Usage

```
KSCovsup(data, Nsim = 1000)
```

Arguments

data	The list variable containing k groups of presmoothed functional observations. Each element of the list is a p (number sampling points) by n (sample size) matrix.
Nsim	Number of pseudo samples by resampling, default=1000.

Details

Sup-norm test of equality of several covariance functions, see GUO et al. (2017).

Value

The p-value of the test.

References

GUO et al. (2017).

See Also

KSCovL2WS, KSCovL2.

Examples

```
fdata<-list();
fdata[[1]]<-matrix(rnorm(200),20,10);
fdata[[1]]<-matrix(rnorm(300),20,15);
KSCovsup(fdata)
KSCovsup(fdata, 500)
```

oneSPL *oneSPL of L2-norm test*

Description

Generate one pseudo sample by resampling and compute the value of the L2-norm test statistic.

Usage

```
oneSPL(odata, sample_num, k, p, n)
```

Arguments

`odata`	The list variable containing k groups of presmoothed functional observations. Each element of the list is a p (number sampling points) by n (sample size) matrix.
`sample_num`	vector of group sizes.
`k`	number of groups.
`p`	number of time points.
`n`	total number of samples.

Details

The input data should have been centered. This function is obsolete and implemented in R, for testing purpose only. Should use `oneSPLL2` instead.

Value

The value of test statistic.

References

ZHANG (2013), GUO et al. (2016).

See Also

`oneSPLL2`, `oneSPLmax`.

Examples

```
p <- 100; sample_num <- c(40,60); k <- length(sample_num); n <- sum(sample_num);
odata <- matrix(rnorm(p*n),p,n);
oneSPL(odata, sample_num, k, p, n);
```

oneSPLL2 *oneSPL of L2-norm test*

Description

Generate one pseudo sample by resampling and compute the value of the L2-norm test statistic.

Usage

```
oneSPLL2(odata, sample_num, k, p, n)
```

Arguments

odata	The list variable containing k groups of presmoothed functional observations. Each element of the list is a p (number sampling points) by n (sample size) matrix.
sample_num	vector of group sizes.
k	number of groups.
p	number of time points.
n	total number of samples.

Details

The input data should have been centered.

Value

The value of test statistic.

References

ZHANG (2013), GUO et al. (2016).

See Also

oneSPL, oneSPLmax.

Examples

```
p <- 100; sample_num <- c(40,60); k <- length(sample_num); n <- sum(sample_num);
odata <- matrix(rnorm(p*n),p,n);
oneSPL(odata, sample_num, k, p, n);
```

oneSPLmax *oneSPL of sup-norm test*

Description

Generate one pseudo sample by resampling and compute the value of the sup-norm test statistic.

Usage

```
oneSPLmax(odata, sample_num, k, p, n)
```

Arguments

odata	The list variable containing k groups of presmoothed functional observations. Each element of the list is a p (number sampling points) by n (sample size) matrix.
sample_num	vector of group sizes.
k	number of groups.
p	number of time points.
n	total number of samples.

Details

The input data should have been centered.

Value

The value of test statistic.

References

ZHANG (2013), GUO et al. (2016).

See Also

oneSPL, oneSPLL2.

Examples

```
p <- 100; sample_num <- c(40,60); k <- length(sample_num); n <- sum(sample_num);
odata <- matrix(rnorm(p*n),p,n);
oneSPL(odata, sample_num, k, p, n);
```

RcppArmadillo-Functions *Set of functions in ECPsup package*

Description

Tests for equal covariance functions problem, implemented in C++.

Usage

```
rcpparma_L2stat(V, sample_num, k, p, n);
rcpparma_fKSCovL2(data, sample_num, k, p, n, Nsim);
rcpparma_maxstat(V, sample_num, k, p, n);
rcpparma_fKSCovsup(data, sample_num, k, p, n, Nsim);
```

Arguments

V	centered data matrix
data	data matrix
sample_num	sample sizes vector
k	number of groups
p	number of time points
n	total number of samples
Nsim	number of pseudo samples by resampling

Details

These are cpp versions of the tests for the ECF problem.

Value

rcpparma_L2stat returns a numeric value computed as the test statistic of L2-norm test.

rcpparma_fKSCovL2 returns a double computed as the p-value of the L2-norm based test.

rcpparma_maxstat returns a numeric value computed as the test statistic of sup-norm test.

rcpparma_fKSCovsup returns a double computed as the p-value of the sup-norm based test.

Author(s)

Bu Zhou

References

ZHANG (2013), GUO et al. (2016), PAPARODITIS and SAPATINAS (2016), GUO et al. (2017).

Examples

```
vn <- c(20,30,30); k <- length(vn); n <- sum(vn);
p <- 100; Nsim <- 500;
datamx <- matrix(rnorm(p*n),p,n,Nsim);
rcpparma_fKSCovL2(datamx,vn,k,p,n,Nsim);
rcpparma_fKSCovsup(datamx,vn,k,p,n,Nsim);
```

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