Package 'fpcb'

June 7, 2021

Version 0.1.0

Type Package

Title Predictive Confidence Bands for Functional Time Series
Forecasting

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Description Functions to represent functional objects under a Reproducing Ker-
nel Hilbert Space (RKHS) framework as described
in Muñoz & González (2010). Autoregressive Hilbertian Model for functional time series us-
ing RKHS and predictive confidence bands construction
as proposed in Hernández et al (2021).

Encoding UTF-8

License GPL (>= 3)

Imports FNN

Repository CRAN

NeedsCompilation yes

RoxygenNote 7.1.1

BugReports https://github.com/nicolashernandezb/fpcb/issues

Date/Publication 2021-06-07 06:50:13 UTC

R topics documented:

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fpcb-package   *Predictive confidence bands for functional time series forecasting*

Description

Functions to represent functional objects under a Reproducing Kernel Hilbert Space (RKHS) framework as described in Muñoz & González (2010). <doi:10.1016/j.patrec.2009.07.014>. Autoregressive Hilbertian Model for functional time series using RKHS and predictive confidence bands construction as proposed in Hernández et al (2021) <arXiv:2105.13627>.

Author(s)

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References

- A. Muñoz, J. González, Representing functional data using support vector machines, Pattern Recognition Letters 31 (2010) 511–516. <doi:10.1016/j.patrec.2009.07.014>.
- Martos, G. et al (2018): Entropy Measures for Stochastic Processes with Applications in Functional Anomaly Detection. Entropy 20(1): 33 (2018). <doi:10.3390/e20010033>.
- D. Wang, Z. Zhao, R. Willett, C. Y. Yau, Functional autoregressive processes in reproducing kernel hilbert spaces, arXiv preprint arXiv:2011.13993 (2020).
- N. Hernández, J. Cugliari, J. Jacques. Simultaneous Predictive Bands for Functional Time Series using Minimum Entropy Sets. arXiv:2105.13627 (2021).

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arh_rkhs   *Autoregressive Hilbertian Model using RKHS*

Description

Estimates an autoregresive Hilbertian model of order 1 for functional time series. The temporal dependence is estimated in the Hilbert projection space which has a reproducing kernel as proposed in Hernández et al (2021) <arXiv:2105.13627> and Wang et al (2020) <arXiv:2011.13993>.

Usage

```
arh_rkhs(fdata)
```

Arguments

fdata   an fdata object containing the functional objects and the lambda coefficients of
                 the d dimensional RKHS representation.

Value

`fdata`	smoothed curves.
`lambda_cent`	centered coefficients of the d dimensional RKHS representation.
`lambda_ce`	average coefficients of the d dimensional RKHS representation.
`rho`	autocorrelation operator computed as: $Gamma_0 Psi = Gamma_1$. $Gamma_0$ correspond to the Covariance and $Gamma_0$ correspond to the Cross-Covariance (of lag 1) operators, both estimated using the coefficients $lambda$.

Author(s)

N. Hernández and J. Cugliari

References

N. Hernández, J. Cugliari, J. Jacques. Simultaneous Predictive Bands for Functional Time Series using Minimum Entropy Sets. arXiv:2105.13627 (2021). D. Wang, Z. Zhao, R. Willett, C. Y. Yau, Functional autoregressive processes in reproducing kernel hilbert spaces, arXiv preprint arXiv:2011.13993 (2020).

`fdata_rkhs`	*functional data in rkhs*

Description

Representing functinal data using Reproducing Kernel Hilbert Spaces. Approximate each curve with a smooth function using a kernel function.

Usage

```
fdata_rkhs(curves, rk, gamma = 1e-05)
```

Arguments

`curves`	a data matrix with observations (curves) in rows and the discretizations points in columns.
`rk`	kernek function rk object.
`gamma`	regularization parameter. Defaoult value = 1e-5.

Details

With this function each function can be represented with a vector in R^d.

Value

`data`	input curves.
`fdata`	smoothed curves.
`lambda`	coefficients of the (stable) and d dimensional RKHS representation.
`alpha`	coefficients of the RKHS expansion.
`gamma`	regularization parameter.

Author(s)

N. Hernández and J. Cugliari

References

A. Muñoz, J. González, Representing functional data using support vector machines, Pattern Recognition Letters 31 (2010) 511–516. <doi:10.1016/j.patrec.2009.07.014>.

Examples

```
t = 1:50
curves = matrix(sin(t)+rnorm(length(t)),nrow=1)
f.data <- fdata_rkhs(curves, rk = rk(t,sigma = 0.01))
plot(t,curves, xlab='time', ylab='PM10 dataset', col='gray', lty=1, type='b')
lines(t,f.data$fdata, col='blue', lty=1)
```

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predict_rkhs   *Predict functional time series using ARH RKHS.*

Description

using an ARH of order 1 obtain 1 step ahead forecast and 1-$alpha$ predictive confidence bands for the forecasted function.

Usage

```
predict_rkhs(
  model,
  newdata,
  bands = FALSE,
  B = 100,
  level = 0.95,
  kvec = round(sqrt(2 * B))
)
```

Arguments

model
: a arh_rkhs object containing the functional objects and the lambda coefficients of the d dimensional RKHS representation and the autocorrelation operator.

newdata
: an optional data frame in which to look for variables with which to predict. If missing, the fitted values are used.

bands
: logical variable indicating if the predictive confidence band is computed. Default = FALSE.

B
: number of bootstrap replicates for the band construction. Needed if bands = TRUE. Default = 100.

level
: confidence level for the band construction. Needed if bands = TRUE. Default = 0.95.

kvec
: number of neighbour points to consider in the computation of the minimum entropy set.

Value

forecast
: 1 step ahead forecast.

fitted
: fitted values.

UB
: upper bound of the 1-$alpha$ predictive confidence band.

LB
: lower bound of the 1-$alpha$ predictive confidence band.

bootsrap.pred
: bootstrap pseudo replicates.

bootsrap.pred.inband
: bootstrap pseudo replicates included in the 1-$alpha$ predictive confidence band.

res
: estimation residuals.

Author(s)

N. Hernández and J. Cugliari

References

N. Hernández, J. Cugliari, J. Jacques. Simultaneous Predictive Bands for Functional Time Series using Minimum Entropy Sets. arXiv:2105.13627 (2021).

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rk   *kernel function*

Description

Computes the Gram matrix of the gaussian kernel over a grid of values and computes its singular value decomposition.

Usage

```
rk(grid, sigma = 1, r, tol = 1e-08)
```

Arguments

`grid`	grid of points where the kernel function is evaluated.
`sigma`	is the temperature of the kernel (standard deviation)
`r`	the dimension of the basis system of the Gran matrix (K). If missing then r is the rank of K.
`tol`	A tolerance to keep the first d eigenvalues of A. Default = 1e-08.

Value

`grid`	grid of points where the kernel function is evaluated.
`K`	Kernel Gram matrix
`U`	first r eigenvectors of K using svd.
`D`	first r eigenvectors of K using svd.

Author(s)

J. Cugliari and N. Hernández

Examples

```
grid = seq(0,1,,100)
rk(grid, sigma = 1)
```

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