Package ‘mgwrsar’

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bandwidths_mgwrsar

Description

Given a lm formula and a dataframe with coordinates, function bandwidths_mgwrsar optimizes the choice of a bandwidth value for each of the chosen models and kernel types using a leave-one-out cross validation criteria. A cross validated criteria is also used for selecting the best kernel type for a given model.

Usage

bandwidths_mgwrsar(formula, data, coord,
                    fixed_vars='Intercept', Models='GWR', Kernels_candidates='bisq',
                    control=list(), control_search=list())

Arguments

formula a formula.
data a dataframe or a spatial dataframe (sp package).
coord a dataframe or a matrix with coordinates, not required if data is a spatial dataframe, default NULL.
fixed_vars a vector with the names of spatially constant coefficient. For mixed model, if NULL, the default # is set to 'Intercept'.
Models character containing the type of model: Possible values are "OLS", "SAR", "GWR" (default), "MGWR", "MGWRSAR_0_0_kv", "MGWRSAR_1_0_kv", "MGWRSAR_0_kc_kv", "MGWRSAR_1_kc_kv", "MGWRSAR_1_kc_0".
Kernels_candidates a vector with the names of kernel type.
control list of extra control arguments for MGWRSAR wrapper - see MGWRSAR help.
control_search list of extra control arguments for bandwidth/kernel search - see section below.

@details

- search_Wif TRUE select an optimal spatial weight matrix using a moment estimator, default FALSE.
- kernels_wif search_W is TRUE, kernels_w is a vector of candidated kernels types, default NULL.
• lower_clower bound for bandwidth search (default, the approximate first decile of distances).
• upper_cupper bound for bandwidth search (default, the approximate last decile of distances).
• lower_dlower bound for discrete kernels, default 2*k+1.
• lower_dWlower bound for discrete kernels for finding optimal spatial weight matrix, default 2.
• lower_cWlower bound for bandwidth search for finding optimal spatial weight matrix (default approximate 0.005 quantile of distances).

Details
Given a lm formula and a dataframe with coordinates, for each model in Models for which a bandwidth is required, this function optimizes the choice of a bandwidth value for each of the chosen models and kernel types using a leave one out cross validation criteria. A cross validated criteria is also used for selecting the best kernel type for a given model.

Value

bandwidths_MGWRSAR returns a list with:

config_model a vector with information about model, optimal kernel and bandwidth for local regression, and optimal kernel and bandwidth for spatial weight matrix W.
SSR The sum of square residuals.
CV The CV criteria.
model objects of class mgwrsar estimated using config_model

References


See Also

MGWRSAR, summary_mgwrsar, plot_mgwrsar, predict_mgwrsar

Examples

library(mgwrsar)
## loading data example
data(mydata)
find_TP

Search of a suitable set of target points. find_TP is a wrapper function that identifies a set of target points based on spatial smoothed OLS residuals.

Description

Search of a suitable set of target points. find_TP is a wrapper function that identifies a set of target points based on spatial smoothed OLS residuals.

Usage

find_TP(formula, data, coord, K, kWtp=16, Wtp=NULL, type='residuals', model_residuals=NULL, verbose=0, prev_TP=NULL, nTP=NULL)

Arguments

- **formula**: a formula
- **data**: a dataframe or a spatial dataframe (SP package)
- **coord**: a dataframe or a matrix with coordinates, not required if data is a spatial dataframe
- **K**: the minimum number of first neighbors with lower (resp. higher) absolute value of the smoothed residuals.
- **kWtp**: the number of first neighbors for computing the smoothed residuals, default 16.
- **Wtp**: a precomputed matrix of weights, default NULL.
- **type**: method for choosing TP, could be 'residuals', 'equidistantGrid', 'random', default 'residuals'
- **model_residuals**: (optional) a vector of residuals.
- **verbose**: verbose mode, default FALSE.
- **prev_TP**: index of already used TP (version length(K)>1), default NULL.
- **nTP**: number of target points for random choice of target points, default NULL.
**Details**

find_TP is a wrapper function that identifies a set of target points, based on spatial smoothed residuals by default. If no vector of residuals are provided, OLS residuals are computed. The function first computes the smooth of model residuals using a Sheppard’s kernel with kWtp neighbors (default 16). Then it identifies local maxima (resp. minima) that fits the requirement of having at least K neighbors with lower (resp. higher) absolute value of the smoothed residuals. As K increases the number of target points decreases.

**Value**

find_TP returns an index vector of Target Points set.

**Examples**

```r
library(mgwrssar)
## loading data example
data(mydata)
coord=as.matrix(mydata[,c("x_lat","y_lon")])
TP=find_TP(formula = 'Y_gwr~X1+X2+X3', data =mydata,coord=coord,K=6,type='residuals')
# only 60 targets points are used
length(TP)

model_GWR_tp<-MGWRSAR(formula = 'Y_gwr~X1+X2+X3', data = mydata,coord=coord, fixed_vars=NULL,kernels=c('gauss'), H=0.03, Model = 'GWR', control=list(SE=TRUE,TP=TP,kWtp=12))
summary(model_GWR_tp$Betav)
```

----

**kernel_matW**

A function that returns a sparse weight matrix based computed with a specified kernel (gauss,bisq,tcub,epane,rectangle,triangle) considering coordinates provides in S and a given bandwidth. If NN<ncol(S) only NN firts neighbours are considered. If Type!='GD' then S should have additional columns and several kernels and bandwidths should be be specified by the user.

**Description**

kernel_matW A function that returns a sparse weight matrix based computed with a specified kernel (gauss,bisq,tcub,epane,rectangle,triangle) considering coordinates provides in S and a given bandwidth. If NN<ncol(S) only NN firts neighbours are considered. If Type!='GD' then S should have additional columns and several kernels and bandwidths should be be specified by the user.

**Usage**

kernel_matW(H,kernels,coord_i,coord_j=NULL,NN,ncolX=1, Type='GD',adaptive=F,diagnull=TRUE,rowNorm=TRUE)
Arguments

H
A vector of bandwidths

kernels
A vector of kernel types

coord_i
A matrix with variables used in kernel (reference)

coord_j
A matrix with variables used in kernel (neighbors), default NULL (if NULL coord_j=coord_i)

NN
Number of spatial Neighbours for kernels computations

ncolX
control parameter

Type
Type of Generalized kernel product (‘GD’ only spatial,’GDC’ spatial + a categorical variable,’GDX’ spatial + a continuous variable, ’GDT’ spatial + a time index, and other combinations ‘GDXXC’,’GDTX’,...)

adaptive
A vector of boolean to choose adaptive version for each kernel

diagnull
Zero on diagonal, default FALSE

rowNorm
A boolean, row normalization of weights, default TRUE

Value

A sparse Matrix of weights (dgCMatrix).

Examples

library(mgwrsar)
## loading data example
data(mydata)
coord=as.matrix(mydata[,c("x_lat","y_lon")])
## Creating a spatial weight matrix (sparse dgCMatrix) of 4 nearest neighbors with 0 in diagonal
W=kernel_matW(H=4,kernels='rectangle',coord_i=coord,NN=4,adaptive=TRUE,diagnull=TRUE,rowNorm=TRUE)

MGWRSAR

Estimation of linear and local linear model with spatial autocorrelation model (mgwrsar).

Description

MGWRSAR is a wrapper function for estimating linear and local linear models with spatial autocorrelation (SAR models with spatially varying coefficients).

Usage

MGWRSAR(formula,data,coord,fixed_vars=NULL,kernels,H,
Model='GWR',control=list())
Arguments

- **formula**: a formula.
- **data**: a dataframe or a spatial dataframe (sp package).
- **coord**: default NULL, a dataframe or a matrix with coordinates, not required if data is a spatial dataframe.
- **fixed_vars**: a vector with the names of spatially constant coefficient for mixed model. All other variables present in formula are supposed to be spatially varying. If empty or NULL (default), all variables in formula are supposed to be spatially varying.
- **kernels**: A vector containing the kernel types. Possible types: rectangle ("rectangle"), bisquare ("bisq"), tricube ("tcub"), epanechnikov ("epane"), gaussian ("gauss")
- **H**: vector containing the bandwidth parameters for the kernel functions.
- **Model**: character containing the type of model: Possible values are "OLS", "SAR", "GWR" (default), "MGWR", "MGWRSAR_0_0_kv","MGWRSAR_1_0_kv", "MGWRSAR_0_1_kcv","MGWRSAR_1_1_kcv", "MGWRSAR_1_1_kcv_0". See Details for more explanation.
- **control**: list of extra control arguments for MGWRSAR wrapper - see Details below

Details

- **Z**: a matrix of variables for generalized kernel product, default NULL.
- **W**: a row-standardized spatial weight matrix for Spatial Aurocorrelation, default NULL.
- **type**: verbose mode, default FALSE.
- **adaptive**: a vector of boolean to choose adaptive version for each kernel.
- **kernel_w**: the type of kernel for computing W, default NULL.
- **h_w**: the bandwidth value for computing W, default 0.
- **Method**: estimation technique for computing the models with Spatial Dependence. '2SLS' or 'B2SLS', default '2SLS'.
- **TP**: A vector of target points, default NULL.
- **isgcv**: computing LOOCV criteria (for example for selecting optimal bandwidth), default FALSE.
- **isfgcv**: if TRUE, simplify the computation of CV criteria (remove or not i when using local instruments for model with lambda spatially varying), default TRUE.
- **maxknn**: when n > NmaxDist, only the maxknn first neighbours are used for distance computation, default 500.
- **NmaxDist**: when n > NmaxDist only the maxknn first neighbours are used for distance computation, default 5000.
- **verbose**: verbose mode, default FALSE.
MGWRSAR returns an object of class mgwrsar with at least the following components:

- **Betav**: Matrix of coefficients of dim(n,kv) x kv.
- **Betac**: Vector of coefficients of length kc.
- **Model**: The sum of square residuals.
- **Y**: The dependent variable.
- **XC**: The explanatory variables with constant coefficients.
- **XV**: The explanatory variables with varying coefficients.
- **X**: The explanatory variables.
- **W**: The spatial weight matrix for spatial dependence.
- **isgcv**: If gcv has been computed.
- **edf**: The estimated degrees of freedom.
- **formula**: The formula.
- **data**: The dataframe used for computation.
- **Method**: The type of model.
- **coord**: The spatial coordinates of observations.
- **H**: The bandwidth vector.
- **fixed_vars**: The names of constant coefficients.
- **kernels**: The kernel vector.
- **SSR**: The sum of square residuals.
- **residuals**: The vector of residuals.
- **fit**: The vector of fitted values.
- **sev**: Local standard error of parameters.
- **NN**: Maximum number of neighbors for weights computation.

MGWRSAR is a wrapper function for estimating linear and local linear model with spatial autocorrelation that allows to estimate the following models:

\[ y = \beta_c X_c + \beta_v(u_i,v_i)X_v + \epsilon_i \] (MGWR-SAR(0,k,0))
\[ y = \lambda W y + \beta_c X_c + \beta_v(u_i,v_i)X_v + \epsilon_i \] (MGWR-SAR(0,k,c,k,v))
\[ y = \lambda (u_i,v_i) W y + \beta_c X_c + \beta_v(u_i,v_i)X_v + \epsilon_i \] (MGWR-SAR(1,k,0))
\[ y = \lambda (u_i,v_i) W y + \beta_c X_c + \beta_v(u_i,v_i)X_v + \epsilon_i \] (MGWR-SAR(1,k,c,k,v))

When model imply spatial autocorrelation, a row normalized spatial weight matrix must be provided. 2SLS and Best 2SLS method can be used. When model imply local regression, a bandwidth and a kernel type must be provided. Optimal bandwidth can be estimated using bandwidths_mgwrsar function. When model imply mixed local regression, the names of stationary covariates must be provided.
In addition to the ability of considering spatial autocorrelation in GWR/MGWR like models, MGWRSAR function introduces several useful techniques for estimating local regression with space coordinates:

- It uses RCCP and RCCPeigen code that speed up computation and allows parallel computing via doMC package;
- It allows to drop out variables with not enough local variance in local regression, which allows to consider dummies in GWR/MGWR framework without trouble.
- It allows to drop out local outliers in local regression.
- It allows to consider additional variable for kernel, including time (asymmetric kernel) and categorical variables (see Li and Racine 2010). Experimental version.

References


See Also

bandwidths_mgwrsar, summary_mgwrsar, plot_mgwrsar, predict_mgwrsar, kernel_matW

Examples

```r
library(mgwrsar)
## loading data example
data(mydata)
coord=as.matrix(mydata[,c("x_lat","y_lon")])
## Creating a spatial weight matrix (sparse dgCMatrix)
## of 4 nearest neighbors with 0 in diagonal
W=kernel_matW(H=4,kernels='rectangle',coord_i=coord,NN=4,adaptive=TRUE,
diagnull=TRUE,rowNorm=TRUE)
mgwrsar_0_kc_kv<-MGWRSAR(formula = 'Y_mgwrsar_0_kc_kv~X1+X2+X3', data = mydata,
coord=coord, fixed_vars='X2',kernels=c('gauss'),H=20, Model = 'MGWRSAR_0_kc_kv',
control=list(SE=FALSE,adaptive=TRUE,W=W))
summary_mgwrsar(mgwrsar_0_kc_kv)
```
A bootstrap test for Betas for mgwrsar class model.

Usage

mgwrsar_bootstrap_test(x0, x1, B = 100, domc = FALSE, ncore = 1, type = 'standard', eps = 'H1', df = 'H1', focal = 'median', D = NULL)

Arguments

- **x0** The H0 mgwrsar model
- **x1** The H1 mgwrsar model
- **B** number of bootstrap repetitions, default 100
- **domc** If TRUE, doParallel parallelization
- **ncore** number of cores
- **type** type of bootstrap: 'wild', 'Rademacher', 'spatial' or 'standard' (default)
- **eps** Hypothesis under which residuals are simulated, 'H0' or 'H1' (default)
- **df** Hypothesis under which degree of freedom is estimated.
- **focal** see sample_stat help
- **D** A matrix of distance

Value

The value of the statistic test and a p ratio.

See Also

mgwrsar_bootstrap_test_all
A bootstrap test for testing nullity of all Betas for mgwrsar class model.

**Usage**

```r
mgwrsar_bootstrap_test_all(model, B=100, domc=NULL)
```

**Arguments**

- `model`: A mgwrsar model
- `B`: number of bootstrap replications, default 100
- `domc`: If TRUE, doMC parallelization

**Value**

a matrix with statistical test values and p ratios

**See Also**

`mgwrsar_bootstrap_test`

---

`mydata`  
*mydata is a simulated data set of a mgwrsar model*

**Description**

mydata is a simulated data set of a mgwrsar model

**Author(s)**

Ghislain Geniaux and Davide Martinetti <ghislain.geniaux@inra.fr>

**References**

**normW**  

**Description**  

normW row normalization of dgCMatrix

**Usage**  

```
normW(W)
```

**Arguments**

- **W**: A dgCMatrix class matrix

**Value**

A row normalized dgCMatrix

---

**plot_effect**  

**Description**  

plot_effect plot_effect is a function that plots the effect of a variable $X_k$ with spatially varying coefficient, i.e $X_k \times \beta_k(u_i,v_i)$ for comparing the magnitude of effects of between variables.

**Usage**  

```
plot_effect(model, sampling=TRUE, nsample=2000, title='')
```

**Arguments**

- **model**: a model of mgwrsar class with some spatially varying coefficients.
- **sampling**: Boolean, if nrow(model$Betav)> 5000 a sample of size nsample is randomly selected, default TRUE.
- **nsample**: integer, size of the sample if sampling is TRUE, default 2000.
- **title**: a title for the plot.
Examples

```r
library(mgwrsar)
## loading data example
data(mydata)
coord=as.matrix(mydata[,c("x_lat","y_lon")])
## Creating a spatial weight matrix (sparse dgCMatrix)
## of 8 nearest neighbors with 0 in diagonal
model_GWR0<-MGWRSAR(formula = 'Y_gwr~X1+X2+X3', data = mydata,coord=coord,
fixed_vars=NULL,kernels=c('gauss'),H=0.13, Model = 'GWR',control=list(SE=TRUE))
plot_effect(model_GWR0)
```

---

**plot_mgwrsar** plots the value of local parameters of a mgwrsar models using a leaflet map.

**Description**

plot_mgwrsar plots the value of local parameters of a mgwrsar models using a leaflet map.

**Usage**

```r
plot_mgwrsar(model,type='coef',var=NULL,crs=NULL,mypalette= "RdYlGn",opacity=1,
fopacity=1,radius=1500)
```

**Arguments**

- **model** a mgwrsar model.
- **type** default 'coef', for plotting the value of the coefficients. Local t-Student could also be plot using 't_coef', residuals using 'residuals' and fitted using 'fitted'.
- **var** Names of variable to plot.
- **crs** A CRS projection.
- **mypalette** A leaflet palette.
- **opacity** Opacity of border color.
- **fopacity** Opacity of fill color.
- **radius** radius of circle for plot of points.

**Value**

A Interactive Web Maps with local parameters plot and Open Street Map layer.

**See Also**

MGWRSAR, bandwidths_mgwrsar, summary_mgwrsar, predict_mgwrsar, kernel_matW
predict_mgwrsar

mgwrsar Model Predictions

predict_mgwrsar is a function for computing predictions of a mgwrsar models. It uses Best Linear Unbiased Predictor for mgwrsar models with spatial autocorrelation.

Usage

predict_mgwrsar(model, newdata, newdata_coord, W = NULL, type = "BPN", h_w = 100, kernel_w = "rectangle", maxobs = 4000, beta_proj = FALSE, method_pred = 'TP', k_extra = 8)

Arguments

- model: a model of mgwrsar class.
- newdata: a matrix or data.frame of new data.
- newdata_coord: a matrix of new coordinates, and eventually other variables if a General Kernel Product is used.
- W: the spatial weight matrix for models with spatial autocorrelation.
- type: Type for BLUP estimator, default "BPN". If NULL use predictions without spatial bias correction.
- h_w: A bandwidth value for the spatial weight matrix.
- kernel_w: kernel type for the spatial weight matrix. Possible types: rectangle ("rectangle"), bisquare ("bisq"), tricube ("tcub"), epanechnikov ("epane"), gaussian ("gauss")
- maxobs: maximum number of observations for exact calculation of \(\text{solve}(I-\rho W)\), default maxobs=4000.

Examples

```r
library(mgwrsar)
## loading data example
data(mydata)
coord = as.matrix(mydata[, c("x_lat", "y_lon")])
## Creating a spatial weight matrix (sparse dgCMatrix)
## of 4 nearest neighbors with 0 in diagonal
model_GWR0 <- MGWRSAR(formula = 'Y_gwr ~ X1 + X2 + X3', data = mydata, coord = coord,
fixed_vars = NULL, kernels = c("gauss"), H = 0.13, Model = 'GWR', control = list(SE = TRUE))
summary_mgwrsar(model_GWR0)
plot_mgwrsar(model_GWR0, type = 'B_coef', var = 'X2')
plot_mgwrsar(model_GWR0, type = 't_coef', var = 'X2')
```
predict_mgwrsar

beta_proj  A boolean, if TRUE the function then return a two elements list(Y_predicted,Beta_proj_out)

method_pred  If method_pred = 'TP' (default) prediction is done by recomputing a MGWR-SAR model with new-data as target points, else if method_pred in ('tWtp_model','model','sheppard') a matrix for projecting estimated betas is used (see details).

k_extra  number of neighbors for local parameter extrapolation if sheppard kernel is used, default 8.

Details

if method_pred = 'tWtp_model', the weighting matrix for prediction is based on the expected weights of outsample data if they were had been added to insample data to estimate the corresponding MGWRSAR (see Geniaux 2022 for further detail), if method_pred = 'sheppard' a sheppard kernel with k_extra neighbours (default 8) is used and if method_pred = 'kernel_model' the same kernel and number of neighbors as for computing the MGWRSAR model is used.

Value

A vector of predictions if beta_proj is FALSE or a list with a vector named Y_predicted and a matrix named Beta_proj_out.

See Also

MGWRSAR, bandwidths_mgwrsar, summary_mgwrsar, plot_mgwrsar, kernel_matW

Examples

library(mgwrsar)
data(mydata)
coord=as.matrix(mydata[,c("x_lat","y_lon")])
length_out=800
index_in=sample(1:1000,length_out)
index_out=(1:1000)[-index_in]

model_GWR_insample<-MGWRSAR(formula = '/quotesingle.Var Y_gwr~X1+X2+X3'/quotesingle.Var, data = mydata[index_in,],
coord=coord[index_in,],fixed_vars=NULL,kernels=c('gauss'),H=8, Model = 'GWR',
control=list(adaptive=TRUE))
summary_mgwrsar(model_GWR_insample)

newdata=mydata[index_out,]
ewdata_coord=coord[index_out,]
newdata$Y_mgwrsar_1_0_kv=0

Y_pred=predict_mgwrsar(model_GWR_insample, newdata=newdata,
newdata_coord=newdata_coord)
head(Y_pred)
head(mydata$Y_gwr[index_out])
sqrt(mean((mydata$Y_gwr[index_out]-Y_pred)^2)) # RMSE
**summary_Matrix**

**Description**

summary_Matrix to be documented

**Usage**

summary_Matrix(object, ...)

**Arguments**

- object to be documented
- ... to be documented

**Value**

to be documented

---

**summary_mgwrsar**

**Print a summary of mgwrsar models**

**Description**

Print a summary of mgwrsar models

**Usage**

summary_mgwrsar(model)

**Arguments**

- model a model of class mgwrsar

**Value**

a summary of mgwrsar models

**See Also**

MGWRSAR, bandwidths_mgwrsar, plot_mgwrsar, predict_mgwrsar, kernel_matW
Examples

```r
library(mgwrsar)
## loading data example
data(mydata)
coord=as.matrix(mydata[,c("x_lat","y_lon")])
## Creating a spatial weight matrix (sparse dgCMatrix)
## of 4 nearest neighbors with 0 in diagonal
W=kernel_matW(H=4,kernels='rectangle',coord_i=coord,NN=4,adaptive=TRUE, diagnull=TRUE,rowNorm=TRUE)
mgwrsar_0_kc_kv<-MGWRSAR(formula = 'Y_mgwrsar_0_kc_kv~X1+X2+X3', data = mydata, coord=coord, fixed_vars='X2',kernels=c('gauss'),H=20, Model = 'MGWRSAR_0_kc_kv', control=list(SE=FALSE,adaptive=TRUE,W=W))
summary_mgwrsar(mgwrsar_0_kc_kv)
```
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