

# Package ‘NonpModelCheck’

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**Type** Package

**Title** Model Checking and Variable Selection in Nonparametric Regression

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**Description** Provides tests of significance for covariates (or groups of covariates) in a fully nonparametric regression model and a variable (or group) selection procedure based on False Discovery Rate. In addition, it provides a function for local polynomial regression for any number of dimensions, using a bandwidth specified by the user or automatically chosen by cross validation or an adaptive procedure. Zambom and Akritas (2014) <[doi:10.5705/ss.2013.112](https://doi.org/10.5705/ss.2013.112)>, Zambom and Akritas (2015) <[doi:10.1016/j.jmva.2014.08.014](https://doi.org/10.1016/j.jmva.2014.08.014)>, Zambom and Akritas (2017) <[doi:10.18637/jss.v077.i10](https://doi.org/10.18637/jss.v077.i10)>.

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group.npvarselec      *Group variable selection for nonparametric regression*

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### Description

Performs group variable selection in a completely nonparametric regression model using hypothesis testing for high-dimensional one-way ANOVA and False Discovery Rate (FDR) corrections.

### Usage

```
group.npvarselec(X, Y, groups, method = "backward", p = 7, fitSPC
  = TRUE, degree.pol = 0, kernel.type = "epanech", bandwidth =
  "CV", gridsize = 10, dim.red = c(1, 10))
```

### Arguments

X	matrix with observations, rows corresponding to data points and columns correspond to covariates.
Y	vector of observed responses.
groups	a variable of type "list" containing, in each item, a vector of indices of the covariates in each group.
method	type of algorithm to run variable selection, options are "backward", "forward" and "forward2".
p	size of the window $W_i$ . See <a href="#">npmodelcheck</a> for details.
fitSPC	a logical indicating whether to use the first supervised principal component (SPC) of each group in the local polynomial fitting. See Details.
degree.pol	degree of the polynomial to be used in the local fit.
kernel.type	kernel type, options are "box", "trun.normal", "gaussian", "epanech", "biweight", "triweight" and "triangular". "trun.normal" is a gaussian kernel truncated between -3 and 3.
bandwidth	bandwidth for the local polynomial fit at each step of the elimination (or selection). Options are: "CV" for leave-one-out cross validation with criterion of minimum MSE to select a unique bandwidth that will be used for all dimensions; "GCV" for Generalized Cross Validation to select a unique bandwidth that will be used for all dimensions; "CV2" for leave-one-out cross validation for each covariate; and "GCV2" for GCV for each covariate. See <a href="#">localpoly.reg</a> .
gridsize	number of possible bandwidths to be searched in cross-validation. <i>Default</i> is set to 10. If cross-validation is not performed, it is ignored.
dim.red	vector with first element indicating 1 for Sliced Inverse Regression (SIR) and 2 for Supervised Principal Components (SPC); the second element of the vector should be number of slices (if SIR), or number of principal components (if SPC). If 0, no dimension reduction is performed. This is used to moderate the curse of dimensionality in the local polynomial estimation at each step of the elimination (or selection). See <a href="#">npmodelcheck</a> for details.

## Details

The selection procedure is based on the nonparametric test [npmodelcheck](#), which for testing the significance of group  $i$ , uses the residuals of the local polynomial regression of all the other covariates that are not in that group. When "fitSPC" is TRUE, the residuals for each test are computed based on the estimated regression curve  $m(S_{(-i)})$ , where  $S$  has  $d$  columns, each containing the first SPC of the corresponding group, and  $S_{(-i)}$  is the matrix  $S$  without column  $i$ .

Backward elimination is done by removing, at each step, the least significant group in the model if its p-value, obtained from the test [npmodelcheck](#), is not significant according to False Discovery Rate (FDR) corrections (Benjamini and Yekutieli, 2001). The final model contains only groups that have significant p-values (based on FDR).

Forward selection is done by adding to the model, at each step, the group with the smallest p-value (when tested with all covariates that are already in the model), if when added, every group in the model is significant according to FDR corrections.

Forward2 selection is as follows: at each step, denote by  $Z = (Z_1, \dots, Z_q)$  the groups in the model and by  $W = (W_1, \dots, W_r)$  the groups not in the model (note that  $(Z, W) = X$ ). Let  $p_j$ ,  $j = 1, \dots, r$ , be the maximum of the set of  $q+1$  p-values obtained from testing each group  $(Z_1, \dots, Z_q, W_j)$ . Add to the model the group corresponding to the smallest  $p_j$  as long as, when added, all the p-values of the groups in the model are significant according to FDR corrections.

See also details of [npmodelcheck](#) and [localpoly.reg](#).

## Value

selected	groups selected
p_values	p-values of the tests of the selected groups

## Author(s)

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## References

- Zambom, A. Z. and Akritas, M. G. (2014). a) Nonparametric Lack-of-fit Testing and Consistent Variable Selection. *Statistica Sinica*, v. 24, pp. 1837-1858.
- Zambom, A. Z. and Akritas, M. G. (2015). b) Significance Testing and Group Variable Selection. *Journal of Multivariate Analysis*, v. 133, pp. 51-60.
- Li, K. C. (1991). Sliced Inverse Regression for Dimension Reduction. *Journal of the American Statistical Association*, 86, 316-327.
- Bair E., Hastie T., Paul D. and Tibshirani R. (2006). Prediction by supervised principal components. *Journal of the American Statistical Association*, 101, 119-137.
- Zambom, A. Z. and Akritas, M. G. (2017) NonpModelCheck: An R Package for Nonparametric Lack-of-Fit Testing and Variable Selection, *Journal of Statistical Software*, 77(10), 1-28.  
doi:10.18637/jss.v077.i10

## See Also

[npmodelcheck](#), [localpoly.reg](#), [npvarselec](#)

localpoly.reg

*Local Polynomial Regression Fitting***Description**

Computes the smoothed response or its derivatives in a nonparametric regression using local polynomial fitting.

**Usage**

```
localpoly.reg(X, Y, points = NULL, bandwidth = "CV",
  gridsize = 30, degree.pol = 0, kernel.type = "epanech",
  deriv = 0)
```

**Arguments**

X	matrix with observations, rows corresponding to data points and columns corresponding to covariates.
Y	vector of observed responses.
points	points at which to get smoothed values. If NULL, estimation is done on the observations of X.
bandwidth	bandwidth, vector, matrix of bandwidths, "CV", "GCV", "CV2", "GCV2" or "Adp". When X is univariate(vector): options for the bandwidth are: "CV" for leave-one-out cross validation with criterion of minimum MSE; "GCV" for Generalized Cross Validation; "Adp" for adaptive bandwidth (see details); a positive vector of same length as X representing a bandwidth that changes with the location of estimation. When X is multivariate(matrix): options for the bandwidth are: "CV" for leave-one-out cross validation with criterion of minimum MSE (search is done in a grid marginally for each covariate); "GCV" for Generalized Cross Validation (search is done in a grid marginally for each covariate); "CV2" for leave-one-out cross validation (search is done in any combination of grids for each covariate); "GCV2" for GCV for each covariate (search is done in any combination of grids for each covariate); or a vector or matrix of the same size as 'points'; See <i>Details</i> .
gridsize	number of possible bandwidths to be searched in cross-validation. If cross-validation is not performed, it is ignored.
degree.pol	degree of the polynomial to be used in the local fit. In the univariate case there is no restriction; in the multivariate case, the degree can be 0,1 or 2.
kernel.type	kernel type, options are "box", "trun.normal", "gaussian", "epanech", "biweight", "triweight" and "triangular". "trun.normal" is a gaussian kernel truncated between -3 and 3.
deriv	order of the derivative of the regression function to be estimated.

## Details

Computes smoothed values using local polynomial fitting with the specified kernel type. If multi-dimensional, a multiplicative(product) kernel is used as weight.

In cross validation, for multivariate X and bandwidth options "CV" and "GCV", the procedure searches individually for each covariate, the bandwidth that produces the smallest MSE from a grid of *gridsize* possible bandwidths evenly distributed between the minimum and maximum/2 distance of any of the points of that covariate. In other words, one separate cross-validation is performed in each dimension of X.

In cross validation, for multivariate X and bandwidth options "CV2" and "GCV2", a d-dimensional (number of covariates) grid is created, where each dimension of the grid is a vector of *gridsize* possible bandwidths evenly distributed between the minimum and maximum/2 distance of any of the points in each covariate. Then a search is done crossing all possible combinations of values of each dimension of the grid, where the resulting vector of bandwidths correspond to those which yeild minimum MSE.

Adaptive bandwidth, for univariate X only, is obtained by a similar procedure to the one proposed by Fan and Gijbels (1995). The interval is split into  $\lceil 1.5 \cdot n / (10 \cdot \log(n)) \rceil$  intervals, a leave-one-out cross validation is performed in each interval to obtain a local bandwidth. These bandwidths are then smoothed to obtain the bandwidth for each point in X.

## Value

X	the same input matrix
Y	the same input response vector
points	points at which smoothed values were computed
bandwidth	bandwidth used for the polynomial fit
predicted	vector with the predicted(smoothed) values

## Author(s)

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## References

Fan J. and Gijbels I. (1995). Data-driven bandwidth selection in local polynomial fitting: Variable Bandwidth and Spatial Adaptation. JRSS-B. Vol 57(2), 371-394.

Wand M. P. and Jones M. C. (1995). Kernel Smoothing. Chapman and Hall.

## See Also

[npvarselect](#), [npmodelcheck](#)

## Examples

```
X = rnorm(100)
Y = X^3 + rnorm(100)
```

```
localpoly.reg(X, Y, degree.pol = 0, kernel.type = "box",
```

```

bandwidth = 1)
localpoly.reg(X, Y, degree.pol = 1, kernel.type = "box",
bandwidth = 1.4)
##--
X = runif(100,-3,3)
Y = sin(1/2*pi*X) + rnorm(100,0,.5)

localpoly.reg(X, Y, degree.pol = 0, kernel.type = "gaussian",
bandwidth = 0.2)
localpoly.reg(X, Y, degree.pol = 1, kernel.type = "gaussian",
bandwidth = 0.3)

```

---

npmodelcheck

*Hypothesis Testing for Covariate or Group effect in Nonparametric Regression*


---

### Description

Tests the significance of a covariate or a group of covariates in a nonparametric regression based on residuals from a local polynomial fit of the remaining covariates using high dimensional one-way ANOVA.

### Usage

```
npmodelcheck(X, Y, ind_test, p = 7, degree.pol = 0, kernel.type =
"epanech", bandwidth = "CV", gridsize = 30, dim.red = c(1, 10))
```

### Arguments

X	matrix with observations, rows corresponding to data points and columns correspond to covariates.
Y	vector of observed responses.
ind_test	index or vector with indices of covariates to be tested.
p	size of the window $W_i$ . See Details.
degree.pol	degree of the polynomial to be used in the local fit.
kernel.type	kernel type, options are "box", "trun.normal", "gaussian", "epanech", "biweight", "triweight" and "triangular". "trun.normal" is a gaussian kernel truncated between -3 and 3.
bandwidth	bandwidth, vector or matrix of bandwidths for the local polynomial fit. If a vector of bandwidths, it must correspond to each covariate of $X_{-(ind\_test)}$ , that is, the covariates not being tested. If "CV", leave-one-out cross validation with criterion of minimum MSE is performed to select a unique bandwidth that will be used for all dimensions of $X_{-(ind\_test)}$ ; if "GCV", Generalized Cross Validation is performed to select a unique bandwidth that will be used for all dimensions of $X_{-(ind\_test)}$ ; if "CV2" leave-one-out cross validation for

each covariate of  $X_{-(ind\_test)}$ ; and if "GCV2", GCV for each covariate of  $X_{-(ind\_test)}$ . It can be a matrix of bandwidths (not to be confused with bandwidth matrix  $H$ ), where each row is a vector of the same dimension of the columns of  $X_{-(ind\_test)}$ , representing a bandwidth that changes with the location of estimation for multidimensional  $X$ . See [localpoly.reg](#).

gridsize	number of possible bandwidths to be searched in cross-validation. If left as <i>default</i> 0, gridsize is taken to be $5+as.integer(100/d^3)$ . If cross-validation is not performed, it is ignored.
dim.red	vector with first element indicating 1 for Sliced Inverse Regression (SIR) and 2 for Supervised Principal Components (SPC); the second element of the vector should be number of slices (if SIR), or number of principal components (if SPC). If 0, no dimension reduction is performed. See Details.

### Details

To test the significance of a single covariate, say  $X_j$ , assume that its observations  $X_{ij}$ ,  $i = 1, \dots, n$ , define the factor levels of a one-way ANOVA. To construct the ANOVA, each of these factor levels is augmented by including residuals from nearby covariate values. Specifically, cell "i" is augmented by the values of the residuals corresponding to observations  $X_{ij}$  for "i" in  $W_i$  ( $W_i$  defines the neighborhood, and has size "p"). These residuals are obtained from a local polynomial fit of the remaining covariates  $X_{-(j)}$ . Then, the test for the significance of  $X_j$  is the test for no factor effects in the high-dimensional one-way ANOVA. See references for further details.

When testing the significance of a group of covariates, the window  $W_i$  is defined using the first supervised principal component (SPC) of the covariates in that group; and the local polynomial fit uses the remaining covariates  $X_{-(ind\_test)}$ .

Dimension reduction (SIR or SPC) is applied on the remaining covariates ( $X_{-(ind\_test)}$ ), which are used on the local polynomial fit. This reduction is used to moderate the effect of the curse of dimensionality when fitting nonparametric regression for several covariates. For SPC, the supervision is done in the following way: only covariates with p-values (from univariate "npmodelcheck" test with  $Y$ )  $< 0.3$  can be selected to compose the principal components. If no covariate has p-value  $< 0.3$ , then the most significant covariate will be the only component. For SIR, the size of the effective dimension reduction space is selected automatically through sequential testing (see references for details).

### Value

bandwidth	bandwidth used for the local polynomial fit
predicted	vector with the predicted values with the remaining covariates
p-value	p-value of the test

### Author(s)

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### References

Zambom, A. Z. and Akritas, M. G. (2014). a) Nonparametric Lack-of-fit Testing and Consistent Variable Selection. *Statistica Sinica*, v. 24, pp. 1837-1858.

Zambom, A. Z. and Akritas, M. G. (2015). b) Significance Testing and Group Variable Selection. *Journal of Multivariate Analysis*, v. 133, pp. 51-60.

Li, K. C. (1991). Sliced Inverse Regression for Dimension Reduction. *Journal of the American Statistical Association*, 86, 316-327.

Bair E., Hastie T., Paul D. and Tibshirani R. (2006). Prediction by supervised principal components. *Journal of the American Statistical Association*, 101, 119-137.

Zambom, A. Z. and Akritas, M. G. (2017) NonpModelCheck: An R Package for Nonparametric Lack-of-Fit Testing and Variable Selection, *Journal of Statistical Software*, 77(10), 1-28.  
doi:10.18637/jss.v077.i10

### See Also

[localpoly.reg](#), [npvarselec](#)

### Examples

```
X = matrix(1,100,5)

X[,1] = rnorm(100)
X[,2] = rnorm(100)
X[,3] = rnorm(100)
X[,4] = rnorm(100)
X[,5] = rnorm(100)
Y = X[,3]^3 + rnorm(100)

npmodelcheck(X, Y, 2, p = 9, degree.pol = 0, kernel.type = "trun.normal",
bandwidth = c(0.85, 0.09, 2.5, 2.2), dim.red = 0) # can use bandwidth = "CV"

# not run: can also try
#npmodelcheck(X, Y, 3, p = 7, degree.pol = 0, kernel.type = "trun.normal",
#bandwidth = "CV", dim.red = c(2,2))

#npmodelcheck(X, Y, c(1,2), p = 11, degree.pol = 0, kernel.type = "box",
#bandwidth = c(0.5, 0.5, 0.5), dim.red = c(1,10))

#npmodelcheck(X, Y, c(3,4), p = 5, degree.pol = 0, kernel.type = "box",
#bandwidth = c(2.8, 2.8, 2.8), dim.red = c(1,20))

#npmodelcheck(rnorm(100), rnorm(100), 1, p = 5, degree.pol = 1,
#kernel.type = "box", bandwidth = .5, dim.red = c(1,20))
```

---

npvarselec

*Variable selection for covariates in nonparametric regression*

---

### Description

Performs variable selection using hypothesis tests of covariates in high-dimensional one-way ANOVA for a completely nonparametric regression model.



**Usage**

```
npvarelec(X, Y, method = "backward", p = 7, degree.pol = 0,
          kernel.type = "epanech", bandwidth = "CV", gridsize = 10,
          dim.red = c(1, 10))
```

**Arguments**

X	matrix with observations, rows corresponding to data points and columns correspond to covariates.
Y	vector of observed responses.
method	type of algorithm to run variable selection, options are "backward", "forward" and "forward2".
p	size of the window $W_i$ . See <a href="#">npmodelcheck</a> for details.
degree.pol	degree of the polynomial to be used in the local fit.
kernel.type	kernel type, options are "box", "trun.normal", "gaussian", "epanech", "biweight", "triweight" and "triangular". "trun.normal" is a gaussian kernel truncated between -3 and 3.
bandwidth	bandwidth for the local polynomial fit at each step of the elimination (or selection). Options are: "CV" for leave-one-out cross validation with criterion of minimum MSE to select a unique bandwidth that will be used for all dimensions; "GCV" for Generalized Cross Validation to select a unique bandwidth that will be used for all dimensions; "CV2" for leave-one-out cross validation for each covariate; and "GCV2" for GCV for each covariate. See <a href="#">localpoly.reg</a> .
gridsize	number of possible bandwidths to be searched in cross-validation. <i>Default</i> is set to 10. If cross-validation is not performed, it is ignored.
dim.red	vector with first element indicating 1 for Sliced Inverse Regression (SIR) and 2 for Supervised Principal Components (SPC); the second element of the vector should be number of slices (if SIR), or number of principal components (if SPC). If 0, no dimension reduction is performed. This is used to moderate the curse of dimensionality in the local polynomial estimation at each step of the elimination (or selection). See <a href="#">npmodelcheck</a> for details.

**Details**

Backward elimination is done by removing, at each step, the least significant covariate in the model if its p-value, obtained from the test [npmodelcheck](#), is not significant according to False Discovery Rate (FDR) corrections (Benjamini and Yekutieli, 2001). The procedure continues until all covariates left have significant p-values based on FDR.

Forward selection is done by adding to the model, at each step, the covariate with the smallest p-value (when tested with all covariates that are already in the model), if when added, every covariate in the model is significant according to FDR corrections.

Forward2 selection as follows: at each step, denote by  $Z = (Z_1, \dots, Z_q)$  the covariates in the model and by  $W = (W_1, \dots, W_r)$  the covariates not in the model (note that  $(Z, W) = X$ ). Let  $p_j$ ,  $j = 1, \dots, r$ , be the maximum of the set of  $q+1$  p-values obtained from testing each the covariates  $(Z_1, \dots, Z_q, W_j)$ . Add to the model the covariate corresponding to the smallest  $p_j$  as long as, when added, all the p-values of the covariates in the model are significant according to FDR corrections.

See also details of [npmodelcheck](#).

### Value

selected            selected covariates  
p\_values            p-values of the tests of the selected covariates

### Author(s)

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### References

Zambom, A. Z. and Akritas, M. G. (2014). a) Nonparametric Lack-of-fit Testing and Consistent Variable Selection. *Statistica Sinica*, v. 24, pp. 1837-1858.

Benjamini, Y. and Yekutieli, D. (2001) The control of false discovery rate in multiple testing under dependency. *Annals of Statistics*, 29, 1165-1188.

Zambom, A. Z. and Akritas, M. G. (2017) NonpModelCheck: An R Package for Nonparametric Lack-of-Fit Testing and Variable Selection, *Journal of Statistical Software*, 77(10), 1-28.  
doi:10.18637/jss.v077.i10

### See Also

[npmodelcheck](#), [localpoly.reg](#), [group.npvarselec](#)

### Examples

```
d = 10
X = matrix(1,90,d)

for (i in 1:d)
  X[,i] = rnorm(90)
Y = X[,3]^3 + X[,6]^2 + sin(1/2*pi*X[,9]) + rnorm(90)

#npvarselec(X, Y, method = "forward", p = 9, degree.pol = 0,
#kernel.type = "trun.normal", bandwidth = "CV")
#-----
#Iter. | Variables in the model
#1     | 3
#2     | 3 9
#3     | 3 9 6
#-----
#
#
#Number of Covariates Selected: 3
#
#Covariate(s) Selected:
#-----
#Covariate Index | p-value
#         3      | 0
#         9      | 7e-14
```

```
#          6          | 0
#-----
```

---

plot3d.localpoly.reg 3d plot from a local polynomial fit

---

## Description

Create a 3d plot from a local polynomial fit of two covariates and a response variable.

## Usage

```
plot3d.localpoly.reg(X,Y, bandwidth = "CV", gridsize = 30,
  degree.pol = 0, kernel.type = "epanech", gridsurface = 30,
  xlab=expression(X_1), ylab=expression(X_2),
  zlab=expression(Y), theta = 30, phi = 30, expand = 0.5,
  col = "lightblue", ltheta = 120, shade = 0.75,
  ticktype = "detailed", pch = 16,...)
```

## Arguments

X	n by 2 matrix with observations, rows corresponding to data points and columns correspond to covariates.
Y	vector of observed responses.
bandwidth	bandwidth, vector or matrix. If "CV", leave-one-out cross validation with criterion of minimum MSE is performed to select a unique bandwidth that will be used for all dimensions of X; if "GCV", Generalized Cross Validation is performed to select a unique bandwidth that will be used for all dimensions of X; if "CV2" leave-one-out cross validation for each covariate; and if "GCV2", GCV for each covariate. It may be a vector for each dimension of the X; or a matrix of bandwidths (not to be confused with bandwidth matrix H), where each row is a vector of size 2, representing a bandwidth that changes with the location of estimation for the grid. See <a href="#">localpoly.reg</a> .
gridsize	number of possible bandwidths to be searched in cross-validation. If left as <i>default</i> 0, gridsize is taken to be $5 + \text{as.integer}(100/d^3)$ . If cross-validation is not performed, it is ignored.
degree.pol	degree of the polynomial to be used in the local fit.
kernel.type	kernel type, options are "box", "trun.normal", "gaussian", "epanech", "biweight", "triweight" and "triangular". "trun.normal" is a gaussian kernel truncated between -3 and 3.
gridsurface	number of points on each axis at which to estimate the local polynomial surface.
xlab	parameter for persp
ylab	parameter for persp
zlab	parameter for persp

theta	parameter for persp
phi	parameter for persp
expand	parameter for persp
col	parameter for persp
ltheta	parameter for persp
shade	parameter for persp
ticktype	parameter for persp
pch	parameter for persp
...	further parameters for plotting persp

### Details

Uses function "persp" to plot the estimated surface of a local polynomial fit in a nonparametric model with two covariates. The surface is estimated at points of a grid with size "gridsurface", which are evenly distributed between the minimum and maximum of the observed predictors. It also adds the observed points to the plot.

### Value

X	the same input matrix
Y	the same input response vector
points	points at which to get smoothed values
bandwidth	bandwidth used for the polynomial fit
predicted	matrix with the predicted values at grid points

### Author(s)

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### See Also

[localpoly.reg](#)

### Examples

```
X = matrix(0,50,2)
X[,1] = runif(50,-2,2)
X[,2] = runif(50,-2,2)
Y = 4*sin(pi*X[,1]) + X[,2] + rnorm(50)
```

```
plot3d.localpoly.reg(X,Y, bandwidth= c(0.44, 1.84), gridsize = 15,
degree.pol = 0, gridsurface=20)
```

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