Package ‘gss’

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R topics documented:

aids ................................................................. 2
bacteriuria ......................................................... 3
buffalo .............................................................. 4
cdsscden .......................................................... 4
cdsscopu .......................................................... 5
cdssden ............................................................ 6
clim ................................................................. 7
ColoCan ............................................................ 7
DiaRet ............................................................... 8
dsscden ............................................................ 9
dsscopu ............................................................ 10
dssden ............................................................. 11
esc ................................................................. 12
eyetrack ........................................................... 12
fitted.ssanova ..................................................... 13
gastric ............................................................ 14
gauss.quad ......................................................... 14
Description

A data set collected by Centers for Disease Control and Prevention concerning AIDS patients who were infected with the HIV virus through blood transfusion.

Usage

data(aids)
bacteriuria

Format
A data frame containing 295 observations on the following variables.

- `incu` Time from HIV infection to AIDS diagnosis.
- `infe` Time from HIV infection to end of data collection (July 1986).
- `age` Age at time of blood transfusion.

Source

---

bacteriuria  Treatment of Bacteriuria

Description
Bacteriuria patients were randomly assigned to two treatment groups. Weekly binary indicator of bacteriuria was recorded for every patient over 4 to 16 weeks. A total of 72 patients were represented in the data, with 36 each in the two treatment groups.

Usage
data(bacteriuria)

Format
A data frame containing 820 observations on the following variables.

- `id` Identification of patients, a factor.
- `trt` Treatments 1 or 2, a factor.
- `time` Weeks after randomization.
- `infect` Binary indicator of bacteriuria (bacteria in urine).

Source

References
### buffalo

**Buffalo Annual Snowfall**

**Description**


**Usage**

```r
data(buffalo)
```

**Format**

A vector of 63 numerical values.

**Source**


### cdsscden

**Evaluating Conditional PDF, CDF, and Quantiles of Smoothing Spline Conditional Density Estimates**

**Description**

Evaluate conditional pdf, cdf, and quantiles of $f(y_1|x,y_2)$ for smoothing spline conditional density estimates $f(y|x)$.

**Usage**

```r
cdsscden(object, y, x, cond, int=NULL)
cpsscden(object, q, x, cond)
cqsscden(object, p, x, cond)
```

**Arguments**

- `object`: Object of class "sscden" or "sscden1".
- `x`: Data frame of x values on which conditional density $f(y_1|x,y_2)$ is to be evaluated.
- `y`: Data frame or vector of y1 points on which conditional density $f(y_1|x,y_2)$ is to be evaluated.
- `cond`: One row data frame of conditioning variables y2.
- `q`: Vector of points on which cdf is to be evaluated.
- `p`: Vector of probabilities for which quantiles are to be calculated.
- `int`: Vector of normalizing constants.
cdsscopu

Details

The arguments x and y are of the same form as the argument newdata in predict.lm, but y in cdsscden can take a vector for 1-D y1.

cpsscden and cqsscden naturally only work for 1-D y1.

Value

cdsscden returns a list object with the following components.

pdf Matrix or vector of conditional pdf f(y1|x,y2), with each column corresponding to a distinct x value.

int Vector of normalizing constants.

cpsscden and cqsscden return a matrix or vector of conditional cdf or quantiles of f(y1|x,y2).

Note

If variables other than factors or numerical vectors are involved in y1, the normalizing constants can not be computed.

See Also

Fitting function sscden and dsscden.

| cdsscopu | Evaluating 1-D Conditional PDF, CDF, and Quantiles of Copula Density Estimates |

Description

Evaluate conditional pdf, cdf, and quantiles of copula density estimates.

Usage

```r
cdsscopu(object, x, cond, pos=1, int=NULL)
cpsscopu(object, q, cond, pos=1)
cqsscopu(object, p, cond, pos=1)
```

Arguments

<table>
<thead>
<tr>
<th>object</th>
<th>Object of class &quot;sscopu&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Vector of points on which conditional pdf is to be evaluated.</td>
</tr>
<tr>
<td>cond</td>
<td>Value of conditioning variables.</td>
</tr>
<tr>
<td>pos</td>
<td>Position of variable of interest.</td>
</tr>
<tr>
<td>int</td>
<td>Normalizing constant.</td>
</tr>
<tr>
<td>q</td>
<td>Vector of points on which conditional cdf is to be evaluated.</td>
</tr>
<tr>
<td>p</td>
<td>Vector of probabilities for which conditional quantiles are to be calculated.</td>
</tr>
</tbody>
</table>
Value
A vector of conditional pdf, cdf, or quantiles.

See Also
Fitting functions `sscoup` and `sscoup2`, and `dsscopu`.

| cdssden | Evaluating Conditional PDF, CDF, and Quantiles of Smoothing Spline Density Estimates |

Description
Evaluate conditional pdf, cdf, and quantiles for smoothing spline density estimates.

Usage
```r
cdssden(object, x, cond, int=NULL)
cpssden(object, q, cond)
cqssden(object, p, cond)
```

Arguments
- `object` Object of class "ssden".
- `x` Data frame or vector of points on which conditional density is to be evaluated.
- `cond` One row data frame of conditioning variables.
- `int` Normalizing constant.
- `q` Vector of points on which conditional cdf is to be evaluated.
- `p` Vector of probabilities for which conditional quantiles are to be calculated.

Details
The argument `x` in `cdssden` is of the same form as the argument `newdata` in `predict.lm`, but can take a vector for 1-D conditional densities.

`cpssden` and `cqssden` naturally only work for 1-D conditional densities of a numerical variable.

Value
`cdssden` returns a list object with the following components.
- `pdf` Vector of conditional pdf.
- `int` Normalizing constant.

`cpssden` and `cqssden` return a vector of conditional cdf or quantiles.
Note

If variables other than factors or numerical vectors are involved in $x$, the normalizing constant can not be computed.

See Also

Fitting function ssden and dssden.

clim Average Temperatures During December 1980 Through February 1981

Description

Average temperatures at 690 weather stations during December 1980 through February 1981.

Usage
data(clim)

Format

A data frame containing 690 observations on the following variables.

- temp  Average temperature, in Celsius.
- geog  Geographic location (latitude,longitude), in degrees, as a matrix.

Source

This is reformulated from the data frame climate in the R package assist by Yuedong Wang and Chunlei Ke.

ColoCan Colorectal Cancer Mortality Rate in Indiana Counties

Description

County-wise death counts of colorectal cancer patients in Indiana during years 2000 through 2004.

Usage
data(ColoCan)

Format

A data frame containing 184 observations on the following variables.
DiaRet

Diabetic Retinopathy

Description

Time to blindness of 197 diabetic retinopathy patients who received a laser treatment in one eye.

event  Death counts.
sex  Gender of population.
wrt  Proportion of Whites.
brt  Proportion of Blacks.
ort  Proportion of other minorities.
lat  Latitude.
lon  Longitude.
geog  Geographic location, derived from lat and lon.
scrn  Colorectal cancer screening rate.
name  County name.

gieg was generated from lat and lon using the code given in the example section.

Source

Dr. Tonglin Zhang.

References


Examples

```r
## Converting latitude and longitude to x-y coordinates
## The 49th county is Marion, where Indianapolis is located.
## Not run: ltln2xy <- function(latlon,latlon0) {
lat <- latlon[,1]*pi/180; lon <- latlon[,2]*pi/180
lt0 <- latlon0[1]*pi/180; ln0 <- latlon0[2]*pi/180
x <- cos(lt0)*sin(lon-ln0); y <- sin(lat-lt0)
cbind(x,y)
}
data(ColoCan)
latlon <- as.matrix(ColoCan[,c("lat","lon")])
ltln2xy(latlon,latlon[49,])
## Clean up
rm(ltln2xy,ColoCan,latlon)
## End(Not run)
```
Usage

data(DiaRet)

Format

A data frame containing 197 observations on the following variables.

- **id**: Patient ID.
- **time1**: Follow-up time of left eye.
- **time2**: Follow-up time of right eye.
- **status1**: Censoring indicator of left eye.
- **status2**: Censoring indicator of right eye.
- **trt1**: Treatment indicator of left eye.
- **trt2**: Treatment indicator of right eye.
- **type**: Type of diabetes.
- **age**: Age of patient at diagnosis.
- **time.t**: Follow-up time of treated eye.
- **time.u**: Follow-up time of untreated eye.
- **status.t**: Censoring indicator of treated eye.
- **status.u**: Censoring indicator of untreated eye.

Source

This is reformatted from the data frame *diabetes* in the R package *timereg* by Thomas H. Scheike.

References


---

dsscden  Evaluating PDF, CDF, and Quantiles of Smoothing Spline Conditional Density Estimates

Description

Evaluate pdf, cdf, and quantiles for smoothing spline conditional density estimates.

Usage

dsscden(object, y, x)
psscden(object, q, x)
qsscden(object, p, x)
d.sscden(object, x, y)
d.sscden1(object, x, y, scale=TRUE)
Arguments

- **object**: Object of class "sscedn" or "ssceden1".
- **x**: Data frame of x values on which conditional density f(y|x) is to be evaluated.
- **y**: Data frame or vector of points on which conditional density f(y|x) is to be evaluated.
- **q**: Vector of points on which cdf is to be evaluated.
- **p**: Vector of probabilities for which quantiles are to be calculated.
- **scale**: Flag indicating whether to use approximate scaling without quadrature.

Details

The arguments x and y are of the same form as the argument newdata in predict.lm, but y in dsscden can take a vector for 1-D responses.

psscden and qsscden naturally only work for 1-D responses.

Value

A matrix or vector of pdf, cdf, or quantiles of f(y|x), with each column corresponding to a distinct x value.

See Also

Fitting function **sscden** and **cdsscden**.

---

**dsscopu**  
*Evaluating Copula Density Estimates*

Description

Evaluate copula density estimates.

Usage

`dsscopu(object, x, copu=TRUE)`

Arguments

- **object**: Object of class "sscopu".
- **x**: Vector or matrix of point(s) on which copula density is to be evaluated.
- **copu**: Flag indicating whether to apply copularization.

Value

A vector of copula density values.
**dssden**

**See Also**

Fitting functions `sscopu` and `sscopu2`.

---

**dssden** *Evaluating PDF, CDF, and Quantiles of Smoothing Spline Density Estimates*

**Description**

Evaluate pdf, cdf, and quantiles for smoothing spline density estimates.

**Usage**

```r
  dssden(object, x)
  pssden(object, q)
  qssden(object, p)
  d.ssden(object, x)
  d.ssden1(object, x)
```

**Arguments**

- `object` Object of class "ssden".
- `x` Data frame or vector of points on which density is to be evaluated.
- `q` Vector of points on which cdf is to be evaluated.
- `p` Vector of probabilities for which quantiles are to be calculated.

**Details**

The argument `x` in `dssden` is of the same form as the argument `newdata` in `predict.lm`, but can take a vector for 1-D densities.

`pssden` and `qssden` naturally only work for 1-D densities.

**Value**

A vector of pdf, cdf, or quantiles.

**See Also**

Fitting function `ssden` and `cdssden`. 
**esc**

*Embryonic Stem Cell from Mouse*

**Description**

Data concerning mouse embryonic stem cell gene expression and transcription factor association strength.

**Usage**

```r
data(esc)
```

**Format**

A data frame containing 1027 genes with the following variables.

- `y1`: Gene expression after 4 days.
- `y2`: Gene expression after 8 days.
- `y3`: Gene expression after 14 days.
- `klf4`: Score of TFAS with KLF4.
- `nanog`: Score of TFAS with NANOG.
- `oct4`: Score of TFAS with OCT4.
- `sox2`: Score of TFAS with SOX2.
- `clusterID`: Cluster identification.

**References**


**eyetrack**

*Eyesight Fixation in Eyetracking Experiments*

**Description**

Eyesight Fixation during some eyetracking experiments in linguistic studies.

**Usage**

```r
data(eyetrack)
```
fitted.ssanova

Format
A data frame containing 13891 observations on the following variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>Time, in ms.</td>
</tr>
<tr>
<td>color</td>
<td>Binary indicator, 1 if eyesight fixed on target or color competitor, a factor.</td>
</tr>
<tr>
<td>object</td>
<td>Binary indicator, 1 if eyesight fixed on target or object competitor, a factor.</td>
</tr>
<tr>
<td>id</td>
<td>Identification of homogeneous sessions, a factor.</td>
</tr>
<tr>
<td>cnt</td>
<td>Multiplicity count.</td>
</tr>
</tbody>
</table>

Source
Dr. Anouschka Foltz.

References

Description
Methods for extracting fitted values and residuals from smoothing spline ANOVA fits.

Usage

```r
# S3 method for class 'ssanova'
fitted(object, ...)
# S3 method for class 'ssanova'
residuals(object, ...)

# S3 method for class 'gssanova'
fitted(object, ...)
# S3 method for class 'gssanova'
residuals(object, type="working", ...)
```

Arguments

- **object**: Object of class "ssanova" or "gssanova".
- **type**: Type of residuals desired, with two alternatives "working" (default) or "deviance".
- **...**: Ignored.

Details
The fitted values for "gssanova" objects are on the link scale, so are the "working" residuals.
gastric  

**Gastric Cancer Data**

**Description**

Survival of gastric cancer patients under chemotherapy and chemotherapy-radiotherapy combination.

**Usage**

data(gastric)

**Format**

A data frame containing 90 observations on the following variables.

- **futime**: Follow-up time, in days.
- **status**: Censoring status.
- **trt**: Factor indicating the treatments: 1 – chemotherapy, 2 – combination.

**Source**


---

```r
gauss.quad
```

**Generating Gauss-Legendre Quadrature**

**Description**

Generate Gauss-Legendre quadratures using the FORTRAN routine `gaussq.f` found on NETLIB.

**Usage**

gauss.quad(size, interval)

**Arguments**

- **size**: Size of quadrature.
- **interval**: Interval to be covered.

**Value**

gauss.quad returns a list object with the following components.

- **pt**: Quadrature nodes.
- **wt**: Quadrature weights.
gssanova

**Fitting Smoothing Spline ANOVA Models with Non-Gaussian Responses**

**Description**

Fit smoothing spline ANOVA models in non-Gaussian regression. The symbolic model specification via formula follows the same rules as in `lm` and `glm`.

**Usage**

```r
gssanova(formula, family, type=NULL, data=list(), weights, subset, offset, na.action=na.omit, partial=NULL, alpha=NULL, nu=NULL, id.basis=NULL, nbasis=NULL, seed=NULL, random=NULL, skip.iter=FALSE)
```

**Arguments**

- **formula**: Symbolic description of the model to be fit.
- **family**: Description of the error distribution. Supported are exponential families "binomial", "poisson", "Gamma", "inverse.gaussian", and "nbinomial". Also supported are accelerated life model families "weibull", "lognorm", and "loglogis".
- **type**: List specifying the type of spline for each variable. See `mkterm` for details.
- **data**: Optional data frame containing the variables in the model.
- **weights**: Optional vector of weights to be used in the fitting process.
- **subset**: Optional vector specifying a subset of observations to be used in the fitting process.
- **offset**: Optional offset term with known parameter 1.
- **na.action**: Function which indicates what should happen when the data contain NAs.
- **partial**: Optional symbolic description of parametric terms in partial spline models.
- **alpha**: Tuning parameter defining cross-validation; larger values yield smoother fits. Defaults are alpha=1 for family="binomial" and alpha=1.4 otherwise.
- **nu**: Inverse scale parameter in accelerated life model families. Ignored for exponential families.
- **id.basis**: Index designating selected "knots".
- **nbasis**: Number of "knots" to be selected. Ignored when id.basis is supplied.
- **seed**: Seed for reproducible random selection of "knots". Ignored when id.basis is supplied.
- **random**: Input for parametric random effects in nonparametric mixed-effect models. See `mkran` for details.
- **skip.iter**: Flag indicating whether to use initial values of theta and skip theta iteration. See `ssanova` for notes on skipping theta iteration.
Details

The model specification via formula is intuitive. For example, \( y \sim x_1 \times x_2 \) yields a model of the form

\[
y = C + f_1(x_1) + f_2(x_2) + f_{12}(x_1, x_2) + e
\]

with the terms denoted by "1", "x1", "x2", and "x1:x2".

The model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

Only one link is implemented for each family. It is the logit link for "binomial", and the log link for "poisson", and "Gamma". For "nbinomial", the working parameter is the log of the probability \( p \); see NegBinomial. For "weibull", "lognorm", and "loglogis", it is the location parameter for the log lifetime.

The selection of smoothing parameters is through direct cross-validation. The cross-validation score used for family="poisson" is taken from density estimation as in Gu and Wang (2003), and those used for other families are derived following the lines of Gu and Xiang (2001).

A subset of the observations are selected as "knots." Unless specified via id.basis or nbasis, the number of "knots" \( q \) is determined by \( \max(30, 10n^{2/9}) \), which is appropriate for the default cubic splines for numerical vectors.

Value

gssanova returns a list object of class c("gssanova","ssanova").

The method summary.gssanova can be used to obtain summaries of the fits. The method predict.ssanova can be used to evaluate the fits at arbitrary points along with standard errors, on the link scale. The method project.gssanova can be used to calculate the Kullback-Leibler projection for model selection. The methods residuals.gssanova and fitted.gssanova extract the respective traits from the fits.

Responses

For family="binomial", the response can be specified either as two columns of counts or as a column of sample proportions plus a column of total counts entered through the argument weights, as in glm.

For family="nbinomial", the response may be specified as two columns with the second being the known sizes, or simply as a single column with the common unknown size to be estimated through the maximum likelihood.

For family="weibull", "lognorm", or "loglogis", the response consists of three columns, with the first giving the follow-up time, the second the censoring status, and the third the left-truncation time. For data with no truncation, the third column can be omitted.

Note

For simpler models and moderate sample sizes, the exact solution of gssanova0 can be faster.

The results may vary from run to run. For consistency, specify id.basis or set seed.

In gss versions earlier than 1.0, gssanova was under the name gssanova1.
Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


Examples

```r
## Fit a cubic smoothing spline logistic regression model
test <- function(x)
  {.3*(1e6*(x^11*(1-x)^6)+1e4*(x^3*(1-x)^10))-2}
x <- (0:100)/100
p <- 1-1/(1+exp(test(x)))
y <- rbinom(x,3,p)
logit.fit <- gssanova(cbind(y,3-y)~x,family="binomial")
## The same fit
logit.fit1 <- gssanova(y/3~x,"binomial",weights=rep(3,101),
  id.basis=logit.fit$id.basis)
## Obtain estimates and standard errors on a grid
est <- predict(logit.fit,data.frame(x=x),se=TRUE)
## Plot the fit and the Bayesian confidence intervals
plot(x,y/3,ylab="p")
lines(x,p,col=1)
lines(x,1-1/(1+exp(est$fit)),col=2)
lines(x,1-1/(1+exp(est$fit+1.96*est$se)),col=3)
lines(x,1-1/(1+exp(est$fit-1.96*est$se)),col=3)
## Fit a mixed-effect logistic model
data(bacteriuria)
bact.fit <- gssanova(infect~trt+time,family="binomial",data=bacteriuria,
  id.basis=(1:820)[bacteriuria$id%in%c(3,38)],random=~1|id)
## Predict fixed effects
predict(bact.fit,data.frame(time=2:16,trt=as.factor(rep(1,15))),se=TRUE)
## Estimated random effects
bact.fit$b
## Clean up
## Not run: rm(test,x,p,y,logit.fit,logit.fit1,est,bacteriuria,bact.fit)
dev.off()
## End(Not run)
```
**Fitting Smoothing Spline ANOVA Models with Non-Gaussian Responses**

**Description**

Fit smoothing spline ANOVA models in non-Gaussian regression. The symbolic model specification via formula follows the same rules as in `lm` and `glm`.

**Usage**

```r
gssanova0(formula, family, type=NULL, data=list(), weights, subset, offset, na.action=na.omit, partial=NULL, method=NULL, varht=1, nu=NULL, prec=1e-7, maxiter=30)

```

```r
gssanova1(formula, family, type=NULL, data=list(), weights, subset, offset, na.action=na.omit, partial=NULL, method=NULL, varht=1, alpha=1.4, nu=NULL, id.basis=NULL, nbasis=NULL, seed=NULL, random=NULL, skip.iter=FALSE)
```

**Arguments**

- **formula**: Symbolic description of the model to be fit.
- **family**: Description of the error distribution. Supported are exponential families "binomial", "poisson", "Gamma", "inverse.gaussian", and "nbinomial". Also supported are accelerated life model families "weibull", "lognorm", and "loglogis".
- **type**: List specifying the type of spline for each variable. See `mkterm` for details.
- **data**: Optional data frame containing the variables in the model.
- **weights**: Optional vector of weights to be used in the fitting process.
- **subset**: Optional vector specifying a subset of observations to be used in the fitting process.
- **offset**: Optional offset term with known parameter 1.
- **na.action**: Function which indicates what should happen when the data contain NAs.
- **partial**: Optional symbolic description of parametric terms in partial spline models.
- **method**: Score used to drive the performance-oriented iteration. Supported are `method="v"` for GCV, `method="m"` for GML, and `method="u"` for Mallows' CL.
- **varht**: Dispersion parameter needed for `method="u"`. Ignored when `method="v"` or `method="m"` are specified.
- **nu**: Inverse scale parameter in accelerated life model families. Ignored for exponential families.
- **prec**: Precision requirement for the iterations.
- **maxiter**: Maximum number of iterations allowed for performance-oriented iteration, and for inner-loop multiple smoothing parameter selection when applicable.
alpha  Tuning parameter modifying GCV or Mallows’ CL.

id.basis  Index designating selected "knots".

nbasis  Number of "knots" to be selected. Ignored when id.basis is supplied.

seed  Seed for reproducible random selection of "knots". Ignored when id.basis is supplied.

random  Input for parametric random effects in nonparametric mixed-effect models. See mkran for details.

skip.iter  Flag indicating whether to use initial values of theta and skip theta iteration. See ssanova for notes on skipping theta iteration.

Details

The model specification via formula is intuitive. For example, \( y \sim x_1 \times x_2 \) yields a model of the form

\[
y = C + f_1(x_1) + f_2(x_2) + f_{12}(x_1, x_2) + e
\]

with the terms denoted by "1", "x1", "x2", and "x1:x2".

The model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

Only one link is implemented for each family. It is the logit link for "binomial", and the log link for "poisson", "Gamma", and "inverse.gaussian". For "nbinomial", the working parameter is the logit of the probability \( p \); see NegBinomial. For "weibull", "lognorm", and "loglogis", it is the location parameter for the log lifetime.

The models are fitted by penalized likelihood method through the performance-oriented iteration as described in the reference. For family="binomial", "poisson", "nbinomial", "weibull", "lognorm", and "loglogis", the score driving the performance-oriented iteration defaults to method="u" with varht=1. For family="Gamma" and "inverse.gaussian", the default is method="v".

gssanova0 uses the algorithm of ssanova0 for the iterated penalized least squares problems, whereas gssanova1 uses the algorithm of ssanova.

In gssanova1, a subset of the observations are selected as "knots." Unless specified via id.basis or nbasis, the number of "knots" \( q \) is determined by \( \max(30, 10n^{2/9}) \), which is appropriate for the default cubic splines for numerical vectors.

Value

- gssanova0 returns a list object of class c("gssanova0", "ssanova0", "gssanova").
- gssanova1 returns a list object of class c("gssanova", "ssanova").

The method summary.gssanova0 or summary.gssanova can be used to obtain summaries of the fits. The method predict.gssanova0 or predict.gssanova can be used to evaluate the fits at arbitrary points along with standard errors, on the link scale. The methods residuals.gssanova and fitted.gssanova extract the respective traits from the fits.
Responses

For family="binomial", the response can be specified either as two columns of counts or as a column of sample proportions plus a column of total counts entered through the argument weights, as in `glm`.

For family="nbinomial", the response may be specified as two columns with the second being the known sizes, or simply as a single column with the common unknown size to be estimated through the maximum likelihood.

For family="weibull", "lognorm", or "loglogis", the response consists of three columns, with the first giving the follow-up time, the second the censoring status, and the third the left-truncation time. For data with no truncation, the third column can be omitted.

Note

The direct cross-validation of `gssanova` can be more effective, and more stable for complex models. For large sample sizes, the approximate solutions of `gssanova1` and `gssanova` can be faster than `gssanova0`.

The results from `gssanova1` may vary from run to run. For consistency, specify `id.basis` or set `seed`.

The method `project` is not implemented for `gssanova0`, nor is the mixed-effect model support through `mkran`.

In `gss` versions earlier than 1.0, `gssanova0` was under the name `gssanova`.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


Examples

```r
## Fit a cubic smoothing spline logistic regression model
test <- function(x)
  {.3*(1e6*(x^11*(1-x)^6)+1e4*(x^3*(1-x)^10))-2}
x <- (0:100)/100
p <- 1-1/(1+exp(test(x)))
y <- rbinom(x,3,p)
logit.fit <- gssanova0(cbind(y,3-y)~x,family="binomial")
## The same fit
logit.fit1 <- gssanova0(y/3~x,"binomial",weights=rep(3,101))
## Obtain estimates and standard errors on a grid
est <- predict(logit.fit,data.frame(x=x),se=TRUE)
```
## Plot the fit and the Bayesian confidence intervals
plot(x,y/3,ylab="p")
lines(x,p,col=1)
lines(x,1-1/(1+exp(est$fit)),col=2)
lines(x,1-1/(1+exp(est$fit+1.96*est$se)),col=3)
lines(x,1-1/(1+exp(est$fit-1.96*est$se)),col=3)
## Clean up
## Not run: rm(test,x,p,y,logit.fit,logit.fit1,est)
dev.off()
## End(Not run)

---

**hzdrate.sshzd**

**Evaluating Smoothing Spline Hazard Estimates**

**Description**

Evaluate smoothing spline hazard estimates by sshzd.

**Usage**

```r
hzdrate.sshzd(object, x, se=FALSE, include=c(object$terms$labels,object$lab.p))
hzdcurve.sshzd(object, time, covariates=NULL, se=FALSE)
survep.sshzd(object, time, covariates=NULL, start=0)
```

**Arguments**

- **object**: Object of class "sshzd".
- **x**: Data frame or vector of points on which hazard is to be evaluated.
- **se**: Flag indicating if standard errors are required.
- **include**: List of model terms to be included in the evaluation.
- **time**: Vector of time points.
- **covariates**: Vector of covariate values.
- **start**: Optional starting times of the intervals.

**Value**

For se=FALSE, hzdrate.sshzd returns a vector of hazard evaluations, and hzdcurve.sshzd returns a vector or columns of hazard curve(s) evaluated on time points at the covariates values. For se=TRUE, hzdrate.sshzd and hzdcurve.sshzd return a list consisting of the following components.

- **fit**: Vector or columns of hazard.
- **se.fit**: Vector or columns of standard errors for log hazard.

survep.sshzd returns a vector or columns of expected survivals based on the cumulative hazards over (start, time) at the covariates values, which in fact are the (conditional) survival probabilities $S(time)/S(start)$. 

---
hzdrate.sshzd2d

Note
For left-truncated data, start must be at or after the earliest truncation point.

See Also
Fitting function sshzd.

hzdrate.sshzd2d  Evaluating 2-D Smoothing Spline Hazard Estimates

Description
Evaluate 2-D smoothing spline hazard estimates by sshzd2d.

Usage
hzdrate.sshzd2d(object, time, covariates=NULL)
survexp.sshzd2d(object, time, covariates=NULL, job=3)

Arguments
object  Object of class "sshzd2d".
time  Matrix or vector of time points on which hazard or survival function is to be evaluated.
covariates  Data frame of covariate values.
job  Flag indicating which survival function to evaluate.

Value
A vector of hazard or survival values.

Note
For job=1,2, survexp.sshzd2d returns marginal survival $S_1(t)$ or $S_2(t)$. For job=3, survexp.sshzd2d returns the 2-D survival $S(t_1,t_2)$.
For hzdrate.sshzd2d and survexp.sshzd2d with job=3, time should be a matrix of two columns. For survexp.sshzd2d with job=1,2, time should be a vector.
When covariates is present, its length should be either 1 or that of time.

See Also
Fitting function sshzd2d.
LakeAcidity

Water Acidity in Lakes

Description

Data extracted from the Eastern Lake Survey of 1984 conducted by the United States Environmental Protection Agency, concerning 112 lakes in the Blue Ridge.

Usage

data(LakeAcidity)

Format

A data frame containing 112 observations on the following variables.

- \texttt{ph}\quad Surface ph.
- \texttt{cal}\quad Calcium concentration.
- \texttt{lat}\quad Latitude.
- \texttt{lon}\quad Longitude.
- \texttt{geog}\quad Geographic location, derived from \texttt{lat} and \texttt{lon}

Details

\texttt{geog} was generated from \texttt{lat} and \texttt{lon} using the code given in the Example section.

Source


References


Examples

```r
## Converting latitude and longitude to x-y coordinates
## Not run: ltln2xy <- function(latlon,latlon0) {
  lat <- latlon[,1]*pi/180; lon <- latlon[,2]*pi/180
  l0 <- latlon0[1]*pi/180; ln0 <- latlon0[2]*pi/180
  x <- cos(l0)*sin(lon-ln0); y <- sin(lat-l0)
  cbind(x,y)
}
data(LakeAcidity)
latron <- as.matrix(LakeAcidity[,c("lat","lon")])
```
m.lat <- (min(latlon[,1])+max(latlon[,1]))/2
m.lon <- (min(latlon[,2])+max(latlon[,2]))/2
ltln2xy(latlon,c(m.lat,m.lon))
## Clean up
rm(ltln2xy,LakeAcidity,latlon,m.lat,m.lon)
## End(Not run)

nlm0

**Minimizing Univariate Functions on Finite Intervals**

**Description**

Minimize univariate functions on finite intervals using 3-point quadratic fit, with golden-section safe-guard.

**Usage**

```r
nlm0(fun, range, prec=1e-7)
```

**Arguments**

- `fun`: Function to be minimized.
- `range`: Interval on which the function to be minimized.
- `prec`: Desired precision of the solution.

**Value**

`nlm0` returns a list object with the following components.

- `estimate`: Minimizer.
- `minimum`: Minimum.
- `evaluations`: Number of function evaluations.

---

**NO2**

**Air Pollution and Road Traffic**

**Description**

A subset of 500 hourly observations collected by the Norwegian Public Roads Administration at Alnabru in Oslo, Norway, between October 2001 and August 2003.

**Usage**

```r
data(NO2)
```

**Format**

A data frame containing 500 observations on the following variables.
Source

Statlib Datasets Archive at http://lib.stat.cmu.edu/datasets, contributed by Magne Aldrin.

Description

Data from an experiment in which a single-cylinder engine was run with ethanol to see how the NOx concentration in the exhaust depended on the compression ratio and the equivalence ratio.

Usage

data(nox)

Format

A data frame containing 88 observations on the following variables.

- **nox**: NOx concentration in exhaust.
- **comp**: Compression ratio.
- **equi**: Equivalence ratio.

Source


References


Description

Daily measurements of ozone concentration and eight meteorological quantities in the Los Angeles basin for 330 days of 1976.

Usage

data(ozone)

Format

A data frame containing 330 observations on the following variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>upo3</td>
<td>Upland ozone concentration, in ppm.</td>
</tr>
<tr>
<td>vdht</td>
<td>Vandenberg 500 millibar height, in meters.</td>
</tr>
<tr>
<td>wdspl</td>
<td>Wind speed, in miles per hour.</td>
</tr>
<tr>
<td>hmdt</td>
<td>Humidity.</td>
</tr>
<tr>
<td>sbtp</td>
<td>Sandburg Air Base temperature, in Celsius.</td>
</tr>
<tr>
<td>sbht</td>
<td>Inversion base height, in foot.</td>
</tr>
<tr>
<td>dpgg</td>
<td>Dagget pressure gradient, in mmHg.</td>
</tr>
<tr>
<td>ibtp</td>
<td>Inversion base temperature, in Fahrenheit.</td>
</tr>
<tr>
<td>vstv</td>
<td>Visibility, in miles.</td>
</tr>
<tr>
<td>day</td>
<td>Calendar day, between 1 and 366.</td>
</tr>
</tbody>
</table>

Source

Unknown.

References


Description

### Usage

data(nox)

### Format

A data frame containing 90 observations on the following variables.

- **year**: Year minted.
- **mil**: Thickness in mils.

### Source


### References


---

### predict.ssanova

**Predicting from Smoothing Spline ANOVA Fits**

### Description

Evaluate terms in a smoothing spline ANOVA fit at arbitrary points. Standard errors of the terms can be requested for use in constructing Bayesian confidence intervals.

### Usage

```r
## S3 method for class 'ssanova'
predict(object, newdata, se.fit=FALSE,
         include=c(object$terms$labels,object$lab.p), ...)

## S3 method for class 'ssanova0'
predict(object, newdata, se.fit=FALSE,
         include=c(object$terms$labels,object$lab.p), ...)

## S3 method for class 'ssanova'
predict1(object, contr=c(1,-1), newdata, se.fit=TRUE,
          include=c(object$terms$labels,object$lab.p), ...)
```
predict.ssanova

Arguments

- **object**: Object of class inheriting from "ssanova".
- **newdata**: Data frame or model frame in which to predict.
- **se.fit**: Flag indicating if standard errors are required.
- **include**: List of model terms to be included in the prediction. The offset term, if present, is to be specified by "offset".
- **contr**: Contrast coefficients.
- **...**: Ignored.

Value

- For `se.fit=FALSE`, `predict.ssanova` returns a vector of the evaluated fit.
- For `se.fit=TRUE`, `predict.ssanova` returns a list consisting of the following components:
  - **fit**: Vector of evaluated fit.
  - **se.fit**: Vector of standard errors.

Note

For mixed-effect models through `ssanova` or `gssanova`, the Z matrix is set to 0 if not supplied. To supply the Z matrix, add a component `random=I(\ldots)` in `newdata`, where the as-is function `I(\ldots)` preserves the integrity of the Z matrix in data frame.

`predict1.ssanova` takes a list of data frames in `newdata` representing x1, x2, etc. By default, it calculates f(x1)-f(x2) along with standard errors. While pairwise contrast is the targeted application, all linear combinations can be computed.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


See Also

Fitting functions `ssanova`, `ssanova0`, `gssanova`, `gssanova0` and methods `summary.ssanova`, `summary.gssanova`, `summary.gssanova0`, `project.ssanova`, `fitted.ssanova`. 
Examples

## THE FOLLOWING EXAMPLE IS TIME-CONSUMING
## Not run:
## Fit a model with cubic and thin-plate marginals, where geog is 2-D
data(LakeAcidity)
fit <- ssanova(ph~log(cal)*geog,,LakeAcidity)
## Obtain estimates and standard errors on a grid
new <- data.frame(cal=1,geog=I(matrix(0,1,2)))
nm <- model.frame(~log(cal)+geog,new)
predict(fit,new,se=TRUE)
## Evaluate the geog main effect
predict(fit,new,se=TRUE,inc="geog")
## Evaluate the sum of the geog main effect and the interaction
predict(fit,new,se=TRUE,inc=c("geog","log(cal):geog"))
## Evaluate the geog main effect on a grid
gird <- seq(-.04,.04,len=21)
new <- model.frame(~geog,list(geog=cbind(rep(grid,21),rep(grid,rep(21,21)))))
est <- predict(fit,new,se=TRUE,inc="geog")
## Plot the fit and standard error
par(pty="s")
contour(grid,grid,matrix(est$fit,21,21),col=1)
contour(grid,grid,matrix(est$se,21,21),add=TRUE,col=2)
## Clean up
rm(LakeAcidity,fit,new,gird,est)
dev.off()

## End(Not run)

predict.sscox

Evaluating Smoothing Spline ANOVA Estimate of Relative Risk

Description

Evaluate terms in a smoothing spline ANOVA estimate of relative risk at arbitrary points. Standard errors of the terms can be requested for use in constructing Bayesian confidence intervals.

Usage

## S3 method for class 'sscox'
predict(object, newdata, se.fit=FALSE,
include=c(object$terms$labels,object$lab.p), ...)

Arguments

  object          Object of class "sscox".
  newdata         Data frame or model frame in which to predict.
  se.fit          Flag indicating if standard errors are required.
  include         List of model terms to be included in the prediction.
  ...             Ignored.
predict.ssllrm

Value

For \( \text{se.fit}=\text{FALSE} \), `predict.sscox` returns a vector of the evaluated relative risk.

For \( \text{se.fit}=\text{TRUE} \), `predict.sscox` returns a list consisting of the following components.

- **fit**: Vector of evaluated relative risk.
- **se.fit**: Vector of standard errors for log relative risk.

Note

For mixed-effect models through `sscox`, the \( Z \) matrix is set to 0 if not supplied. To supply the \( Z \) matrix, add a component `random=I(...)` in `newdata`, where the as-is function `I(...)` preserves the integrity of the \( Z \) matrix in data frame.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

See Also

Fitting functions `sscox` and method `project.sscox`.

---

predict.ssllrm  Evaluating Log-Linear Regression Model Fits

Description

Evaluate conditional density in a log-linear regression model fit at arbitrary \( x \), or contrast of log conditional density possibly with standard errors for constructing Bayesian confidence intervals.

Usage

```r
## S3 method for class 'ssllrm'
predict(object, x, y=object$qd.pt, odds=NULL, se.odds=FALSE, ...)
```

Arguments

- **object**: Object of class "ssllrm".
- **x**: Data frame of \( x \) values.
- **y**: Data frame of \( y \) values; \( y \)-variables must be factors.
- **odds**: Optional coefficients of contrast.
- **se.odds**: Flag indicating if standard errors are required. Ignored when \( \text{odds}=NULL \).
- **...**: Ignored.
Value

For \texttt{odds=NULL}, \texttt{predict.ssanova} returns a vector/matrix of the estimated \( f(y|x) \).

When \texttt{odds} is given, it should match \( y \) in length and the coefficients must add to zero; \texttt{predict.ssanova} then returns a vector of estimated "odds ratios" if \texttt{se.odds=FALSE} or a list consisting of the following components if \texttt{se.odds=TRUE}.

- \texttt{fit} Vector of evaluated fit.
- \texttt{se.fit} Vector of standard errors.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

See Also

Fitting function \texttt{ssllrm}.

---

Description

Print functions for Smoothing Spline ANOVA models.

Usage

```r
# S3 method for class 'ssanova'
print(x, ...)
# S3 method for class 'ssanova0'
print(x, ...)
# S3 method for class 'gssanova'
print(x, ...)
# S3 method for class 'ssden'
print(x, ...)
# S3 method for class 'sscden'
print(x, ...)
# S3 method for class 'sshzd'
print(x, ...)
# S3 method for class 'sscox'
print(x, ...)
# S3 method for class 'ssllrm'
print(x, ...)
# S3 method for class 'summary.ssanova'
print(x, digits=6, ...)
# S3 method for class 'summary.gssanova'
print(x, digits=6, ...)
# S3 method for class 'summary.gssanova0'
print(x, digits=6, ...)
```
project

Arguments

x Object of class ssanova, summary.ssanova, summary.gssanova, or ssden.
digits Number of significant digits to be printed in values.
... Ignored.

See Also

ssanova, ssanova0, gssanova, gssanova0, ssden, ssllrm, sshzd, summary.ssanova, summary.gssanova,
summary.gssanova0.

Description

Calculate Kullback-Leibler projection of smoothing spline ANOVA fits for model diagnostics.

Usage

project(object, ...)
## S3 method for class 'ssanova'
project(object, include, ...)
## S3 method for class 'ssanova9'
project(object, include, ...)
## S3 method for class 'gssanova'
project(object, include, ...)
## S3 method for class 'ssden'
project(object, include, mesh=FALSE, ...)
## S3 method for class 'ssden1'
project(object, include, drop1=FALSE, ...)
## S3 method for class 'sscden'
project(object, include, ...)
## S3 method for class 'sscden1'
project(object, include, ...)
## S3 method for class 'sshzd'
project(object, include, mesh=FALSE, ...)
## S3 method for class 'sscox'
project(object, include, ...)
## S3 method for class 'sshzd1'
project(object, include, ...)
## S3 method for class 'ssllrm'
project(object, include, ...)
Arguments

object

Object of class "ssanova", "gssanova", "ssden", "ssden1", "sscden", "sscden1", "sshzd", "sshzd1", or "ssllrm".

include

List of model terms to be included in the reduced model space. The partial and offset terms, if present, are to be specified by "partial" and "offset", respectively.

mesh

Flag indicating whether to return evaluations of the projection.

drop1

If TRUE, calculate p<-length(include) projections with include[-i], i=1,...,p.

Details

The entropy KL(fit0,null) can be decomposed as the sum of KL(fit0,fit1) and KL(fit1,null), where fit0 is the fit to be projected, fit1 is the projection in the reduced model space, and null is the constant fit. The ratio KL(fit0,fit1)/KL(fit0,null) serves as a diagnostic of the feasibility of the reduced model.

For regression fits, smoothness safe-guard is used to prevent interpolation, and KL(fit0,fit1)+KL(fit1,null) may not match KL(fit0,null) perfectly.

For mixed-effect models from ssanova and gssanova, the estimated random effects are treated as offset.

Value

The functions return a list consisting of the following components.

ratio

KL(fit0,fit1)/KL(fit0,null); the smaller the value, the more feasible the reduced model is.

kl

KL(fit0,fit1).

check

KL(fit0,fit1)/KL(fit0,null)+KL(fit1,null)/KL(fit0,null); a value closer to 1 is preferred.

mesh

The evaluations of the projection.

Note

project.ssden1, project.sscden1, and project.sshzd1 calculates square error projections.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

References

See Also

Fitting functions ssanova, gssanova, ssden, sshzd, and sshzd1.

---

### Sachs

**Protein Expression in Human Immune System Cells**

**Description**

Data concerning protein expression levels in human immune system cells under stimulations.

**Usage**

```r
data(Sachs)
```

**Format**

A data frame containing 7466 cells, with flow cytometry measurements of 11 phosphorylated proteins and phospholipids, on the log10 scale of the original.

- **praf**  Raf phosphorylated at S259.
- **pmek**  Mek1/mek2 phosphorylated at S217/S221.
- **plcg**  Phosphorylation of phospholipase C – γ on Y783.
- **pip2**  Phophatidylinositol 4,5-biphosphate.
- **pip3**  Phophatidylinositol 3,4,5-triphosphate.
- **p44.42** Erk1/erk2 phosphorylated at T202/Y204.
- **pakt3473** AKT phosphorylated at S473.
- **pka**  Phosphorylation of of protein kinase A substrates on 3 sites.
- **pkc**  Phosphorylation of of protein kinase C substrates on S660.
- **p38**  Erk1/erk2 phosphorylated at T180/Y182.
- **pjnk**  Erk1/erk2 phosphorylated at T183/Y185.

**Source**


---

### smolyak

**Generating Smolyak Cubature**

**Description**

Generate delayed Smolyak cubatures using C routines modified from smolyak.c found in Knut Petras’ SMOLPACK.
**Usage**

```r
smolyak.quad(d, k)
smolyak.size(d, k)
```

**Arguments**

- `d`: Dimension of unit cube.
- `k`: Depth of algorithm.

**Value**

- `smolyak.quad` returns a list object with the following components:
  - `pt`: Quadrature nodes in rows of matrix.
  - `wt`: Quadrature weights.
- `smolyak.size` returns an integer.

---

**ssanova**

*Fitting Smoothing Spline ANOVA Models*

**Description**

Fit smoothing spline ANOVA models in Gaussian regression. The symbolic model specification via `formula` follows the same rules as in `lm`.

**Usage**

```r
ssanova(formula, type=NULL, data=list(), weights, subset, offset,
na.action=na.omit, partial=NULL, method="v", alpha=1.4,
varht=1, id.basis=NULL, nbasis=NULL, seed=NULL, random=NULL,
skip.iter=FALSE)
```

**Arguments**

- `formula`: Symbolic description of the model to be fit.
- `type`: List specifying the type of spline for each variable. See `mkterm` for details.
- `data`: Optional data frame containing the variables in the model.
- `weights`: Optional vector of weights to be used in the fitting process.
- `subset`: Optional vector specifying a subset of observations to be used in the fitting process.
- `offset`: Optional offset term with known parameter 1.
- `na.action`: Function which indicates what should happen when the data contain NAs.
- `partial`: Optional symbolic description of parametric terms in partial spline models.
Method for smoothing parameter selection. Supported are method="v" for GCV, method="m" for GML (REML), and method="u" for Mallows’ CL.

**alpha**  
Parameter modifying GCV or Mallows’ CL; larger absolute values yield smoother fits; negative value invokes a stable and more accurate GCV/CL evaluation algorithm but may take two to five times as long. Ignored when method="m" are specified.

**varht**  
External variance estimate needed for method="u". Ignored when method="v" or method="m" are specified.

**id.basis**  
Index designating selected "knots".

**nbasis**  
Number of "knots" to be selected. Ignored when id.basis is supplied.

**seed**  
Seed to be used for the random generation of "knots". Ignored when id.basis is supplied.

**random**  
Input for parametric random effects in nonparametric mixed-effect models. See mkran for details.

**skip.iter**  
Flag indicating whether to use initial values of theta and skip theta iteration. See notes on skipping theta iteration.

**Details**

The model specification via formula is intuitive. For example, \( y \sim x_1 \times x_2 \) yields a model of the form

\[
y = C + f_1(x_1) + f_2(x_2) + f_{12}(x_1, x_2) + e
\]

with the terms denoted by "1", "x1", "x2", and "x1: x2".

The model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

A subset of the observations are selected as "knots." Unless specified via id.basis or nbasis, the number of "knots" \( q \) is determined by \( \max(30, 10n^{2/9}) \), which is appropriate for the default cubic splines for numerical vectors.

Using \( q \) "knots," ssanova calculates an approximate solution to the penalized least squares problem using algorithms of the order \( O(nq^2) \), which for \( q \ll n \) scale better than the \( O(n^3) \) algorithms of ssanova0. For the exact solution, one may set \( q = n \) in ssanova, but ssanova0 would be much faster.

**Value**

ssanova returns a list object of class "ssanova".

The method summary.ssanova can be used to obtain summaries of the fits. The method predict.ssanova can be used to evaluate the fits at arbitrary points along with standard errors. The method project.ssanova can be used to calculate the Kullback-Leibler projection for model selection. The methods residuals.ssanova and fitted.ssanova extract the respective traits from the fits.
Skipping Theta Iteration

For the selection of multiple smoothing parameters, \texttt{nlm} is used to minimize the selection criterion such as the GCV score. When the number of smoothing parameters is large, the process can be time-consuming due to the great amount of function evaluations involved.

The starting values for the \texttt{nlm} iteration are obtained using Algorithm 3.2 in Gu and Wahba (1991). These starting values usually yield good estimates themselves, leaving the subsequent quasi-Newton iteration to pick up the “last 10%” performance with extra effort many times of the initial one. Thus, it is often a good idea to skip the iteration by specifying \texttt{skip.iter=TRUE}, especially in high-dimensions and/or with multi-way interactions.

\texttt{skip.iter=TRUE} could be made the default in future releases.

Note

To use GCV and Mallows’ CL unmodified, set \texttt{alpha=1}.

For simpler models and moderate sample sizes, the exact solution of \texttt{ssanova0} can be faster.

The results may vary from run to run. For consistency, specify \texttt{id.basis} or set \texttt{seed}.

In \texttt{gss} versions earlier than 1.0, \texttt{ssanova} was under the name \texttt{ssanova1}.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


Examples

```r
## Fit a cubic spline
x <- runif(100); y <- 5 + 3*sin(2*pi*x) + rnorm(x)
cubic.fit <- ssanova(y~x)
## Obtain estimates and standard errors on a grid
new <- data.frame(x=seq(min(x),max(x),len=50))
est <- predict(cubic.fit,new,se=TRUE)
## Plot the fit and the Bayesian confidence intervals
plot(x,y,col=1); lines(new$x,est$fit,col=2)
lines(new$x,est$fit+1.96*est$se,col=3)
lines(new$x,est$fit-1.96*est$se,col=3)
## Clean up
## Not run: rm(x,y,cubic.fit,new,est)
```
dev.off()
## End(Not run)

## Fit a tensor product cubic spline
data(nox)
nox.fit <- ssanova(log10(nox)~comp*equi, data=nox)
## Fit a spline with cubic and nominal marginals
nox$comp <- as.factor(nox$comp)
nox.fit.n <- ssanova(log10(nox)~comp*equi, data=nox)
## Fit a spline with cubic and ordinal marginals
nox$comp <- as.ordered(nox$comp)
nox.fit.o <- ssanova(log10(nox)~comp*equi, data=nox)
## Clean up
## Not run: rm(nox, nox.fit, nox.fit.n, nox.fit.o)

 ssanova0 Fitting Smoothing Spline ANOVA Models

Description

Fit smoothing spline ANOVA models in Gaussian regression. The symbolic model specification via
formula follows the same rules as in lm.

Usage

ssanova0(formula, type=NULL, data=list(), weights, subset,
offset, na.action=na.omit, partial=NULL, method="v",
varht=1, prec=1e-7, maxiter=30)

Arguments

formula Symbolic description of the model to be fit.
type List specifying the type of spline for each variable. See mkterm for details.
data Optional data frame containing the variables in the model.
weights Optional vector of weights to be used in the fitting process.
subset Optional vector specifying a subset of observations to be used in the fitting process.
offset Optional offset term with known parameter 1.
na.action Function which indicates what should happen when the data contain NAs.
partial Optional symbolic description of parametric terms in partial spline models.
method Method for smoothing parameter selection. Supported are method="v" for GCV,
method="m" for GML (REML), and method="u" for Mallow’s CL.
varht External variance estimate needed for method="u". Ignored when method="v"
or method="m" are specified.
prec Precision requirement in the iteration for multiple smoothing parameter selection.
maxiter Maximum number of iterations allowed for multiple smoothing parameter selection.


Details
The model specification via formula is intuitive. For example, \( y \sim x_1 \times x_2 \) yields a model of the form
\[
y = C + f_1(x_1) + f_2(x_2) + f_{12}(x_1, x_2) + \epsilon
\]
with the terms denoted by "1", "x1", "x2", and "x1:x2".

The model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

\texttt{ssanova0} and the affiliated methods provide a front end to RKPACK, a collection of RATFOR routines for nonparametric regression via the penalized least squares. The algorithms implemented in RKPACK are of the order \( O(n^3) \).

Value
\texttt{ssanova0} returns a list object of class \texttt{c("ssanova0","ssanova")}.

The method \texttt{summary.ssanova0} can be used to obtain summaries of the fits. The method \texttt{predict.ssanova0} can be used to evaluate the fits at arbitrary points along with standard errors. The methods \texttt{residuals.ssanova} and \texttt{fitted.ssanova} extract the respective traits from the fits.

Note
For complex models and large sample sizes, the approximate solution of \texttt{ssanova} can be faster.

The method \texttt{project} is not implemented for \texttt{ssanova0}, nor is the mixed-effect model support through \texttt{mkran}.

In \texttt{gss} versions earlier than 1.0, \texttt{ssanova0} was under the name \texttt{ssanova}.

Author(s)
Chong Gu, \texttt{<chong@stat.purdue.edu>}

References

Examples
```r
## Fit a cubic spline
x <- runif(100); y <- 5 + 3*sin(2*pi*x) + rnorm(x)
cubic.fit <- ssanova0(y~x,method="m")
## Obtain estimates and standard errors on a grid
new <- data.frame(x=seq(min(x),max(x),len=50))
est <- predict(cubic.fit,new,se=TRUE)
## Plot the fit and the Bayesian confidence intervals
plot(x,y,col=1); lines(new$x,e$t$fit,col=2)
```
```r
lines(new$x, est$fit + 1.96*est$se, col=3)
lines(new$x, est$fit-1.96*est$se, col=3)
## Clean up
## Not run: rm(x,y,cubic.fit,new.est)
dev.off()
## End(Not run)
## Fit a tensor product cubic spline
data(nox)
ox.fit <- ssanova0(log10(nox)~comp*equi,data=nox)
## Fit a spline with cubic and nominal marginals
nox$comp<-as.factor(nox$comp)
ox.fit.n <- ssanova0(log10(nox)~comp*equi,data=nox)
## Fit a spline with cubic and ordinal marginals
nox$comp<-as.ordered(nox$comp)
ox.fit.o <- ssanova0(log10(nox)~comp*equi,data=nox)
## Clean up
## Not run: rm(nox,nox.fit,nox.fit.n,nox.fit.o)
```

---

**ssanova9**  
*Fitting Smoothing Spline ANOVA Models with Correlated Data*

**Description**

Fit smoothing spline ANOVA models with correlated Gaussian data. The symbolic model specification via `formula` follows the same rules as in `lm`.

**Usage**

```r
ssanova9(formula, type=NULL, data=list(), subset, offset,  
na.action=na.omit, partial=NULL, method="v", alpha=1.4, 
varht=1, id.basis=NULL, nbasis=NULL, seed=NULL, cov, 
skip.iter=FALSE)
```

**Arguments**

- `formula`: Symbolic description of the model to be fit.
- `type`: List specifying the type of spline for each variable. See `mkterm` for details.
- `data`: Optional data frame containing the variables in the model.
- `subset`: Optional vector specifying a subset of observations to be used in the fitting process.
- `offset`: Optional offset term with known parameter 1.
- `na.action`: Function which indicates what should happen when the data contain NAs.
- `partial`: Optional symbolic description of parametric terms in partial spline models.
method  Method for smoothing parameter selection. Supported are method="v" for V, method="m" for M, and method="u" for U; see the reference for definitions of U, V, and M.

alpha  Parameter modifying V or U; larger absolute values yield smoother fits. Ignored when method="m" are specified.

varht  External variance estimate needed for method="u". Ignored when method="v" or method="m" are specified.

id.basis  Index designating selected "knots".

nbasis  Number of "knots" to be selected. Ignored when id.basis is supplied.

seed  Seed to be used for the random generation of "knots". Ignored when id.basis is supplied.

cov  Input for covariance functions. See mkcov for details.

skip.iter  Flag indicating whether to use initial values of theta and skip theta iteration. See notes on skipping theta iteration.

fit  ssanova9 fit with ARMA error.

Details

The model specification via formula is intuitive. For example, y~x1*x2 yields a model of the form

\[ y = C + f_1(x_1) + f_2(x_2) + f_{12}(x_1, x_2) + e \]

with the terms denoted by "1", "x1", "x2", and "x1:x2".

The model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

A subset of the observations are selected as "knots." Unless specified via id.basis or nbasis, the number of "knots" q is determined by \( \max(30, 10n^{2/9}) \), which is appropriate for the default cubic splines for numerical vectors.

Using q "knots," ssanova calculates an approximate solution to the penalized least squares problem using algorithms of the order \( O(nq^2) \), which for \( q << n \) scale better than the \( O(n^3) \) algorithms of ssanova0. For the exact solution, one may set \( q = n \) in ssanova, but ssanova0 would be much faster.

Value

ssanova9 returns a list object of class c("ssanova9","ssanova").

The method summary.ssanova9 can be used to obtain summaries of the fits. The method predict.ssanova can be used to evaluate the fits at arbitrary points along with standard errors. The method project.ssanova9 can be used to calculate the Kullback-Leibler projection for model selection. The methods residuals.ssanova and fitted.ssanova extract the respective traits from the fits.

para.arma returns the fitted ARMA coefficients for cov=list("arma",c(p,q)) in the call to ssanova9.
Skipping Theta Iteration

For the selection of multiple smoothing parameters, \texttt{nlm} is used to minimize the selection criterion such as the GCV score. When the number of smoothing parameters is large, the process can be time-consuming due to the great amount of function evaluations involved.

The starting values for the \texttt{nlm} iteration are obtained using Algorithm 3.2 in Gu and Wahba (1991). These starting values usually yield good estimates themselves, leaving the subsequent quasi-Newton iteration to pick up the "last 10\%" performance with extra effort many times of the initial one. Thus, it is often a good idea to skip the iteration by specifying \texttt{skip.iter=TRUE}, especially in high-dimensions and/or with multi-way interactions. \texttt{skip.iter=TRUE} could be made the default in future releases.

Note

The results may vary from run to run. For consistency, specify \texttt{id.basis} or set \texttt{seed}.

Author(s)

Chong Gu, \texttt{<chong@stat.purdue.edu>}

References


Examples

```r
x <- runif(100); y <- 5 + 3*sin(2*pi*x) + rnorm(x)
## independent fit
fit <- ssanova9(y~x,cov=list("known",diag(1,100)))
## AR(1) fit
fit <- ssanova9(y~x,cov=list("arma",c(1,0)))
para arma(fit)
## MA(1) fit
e <- rnorm(101); e <- e[-1]-.5*e[-101]
x <- runif(100); y <- 5 + 3*sin(2*pi*x) + e
fit <- ssanova9(y~x,cov=list("arma",c(0,1)))
para arma(fit)
## Clean up
## Not run: rm(x,y,e,fit)
```
Description

Estimate conditional probability densities using smoothing spline ANOVA models. The symbolic model specification via formula follows the same rules as in \texttt{lm}.

Usage

\begin{verbatim}
sscden(formula, response, type=NULL, data=list(), weights, subset,  
aa.action=na.omit, alpha=1.4, id.basis=NULL, nbasis=NULL,  
seed=NULL, ydomain=as.list(NULL), yquad=NULL, prec=1e-7,  
maxiter=30, skip.iter=FALSE)

sscden1(formula, response, type=NULL, data=list(), weights, subset,  
aa.action=na.omit, alpha=1.4, id.basis=NULL, nbasis=NULL,  
seed=NULL, rho=list("xy"), ydomain=as.list(NULL), yquad=NULL,  
prec=1e-7, maxiter=30, skip.iter=FALSE)
\end{verbatim}

Arguments

\begin{itemize}
\item \texttt{formula}    Symbolic description of the model to be fit.
\item \texttt{response}  Formula listing response variables.
\item \texttt{type}      List specifying the type of spline for each variable. See \texttt{mkterm} for details.
\item \texttt{data}      Optional data frame containing the variables in the model.
\item \texttt{weights}   Optional vector of counts for duplicated data.
\item \texttt{subset}    Optional vector specifying a subset of observations to be used in the fitting process.
\item \texttt{na.action} Function which indicates what should happen when the data contain NAs.
\item \texttt{alpha}    Parameter defining cross-validation scores for smoothing parameter selection.
\item \texttt{id.basis} Index of observations to be used as "knots."
\item \texttt{nbasis}   Number of "knots" to be used. Ignored when \texttt{id.basis} is specified.
\item \texttt{seed}     Seed to be used for the random generation of "knots." Ignored when \texttt{id.basis} is specified.
\item \texttt{ydomain}  Data frame specifying marginal support of conditional density.
\item \texttt{yquad}    Quadrature for calculating integral on Y domain. Mandatory if response variables other than factors or numerical vectors are involved.
\item \texttt{prec}     Precision requirement for internal iterations.
\item \texttt{maxiter}  Maximum number of iterations allowed for internal iterations.
\item \texttt{skip.iter} Flag indicating whether to use initial values of theta and skip theta iteration. See \texttt{ssanova} for notes on skipping theta iteration.
\item \texttt{rho}      rho function needed for sscden1.
\end{itemize}
Details

The model is specified via formula and response, where response lists the response variables. For example, sscden(~y*x, ~y) prescribe a model of the form

\[ \log f(y|x) = g_y(y) + g_{xy}(x, y) + C(x) \]

with the terms denoted by "y", "y:x"; the term(s) not involving response(s) are removed and the constant \( C(x) \) is determined by the fact that a conditional density integrates to one on the y axis. sscden1 does keep terms not involving response(s) during estimation, although those terms cancel out when one evaluates the estimated conditional density.

The model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

A subset of the observations are selected as "knots." Unless specified via id.basis or nbasis, the number of "knots" \( q \) is determined by \( \max(30, 10n^{2/9}) \), which is appropriate for the default cubic splines for numerical vectors.

Value

sscden returns a list object of class "sscden". sscden1 returns a list object of class c("sscden1","sscden"). dsscden and cddsscden can be used to evaluate the estimated conditional density \( f(y|x) \) and \( f(y1|x, y2) \); psscden, qsscden, cpsscden, and cqsscden can be used to evaluate conditional cdf and quantiles.

The methods project.sscden or project.sscden1 can be used to calculate the Kullback-Leibler or square-error projections for model selection.

Note

Default quadrature on the Y domain will be constructed for numerical vectors on a hyper cube, then outer product with factor levels will be taken if factors are involved. The sides of the hyper cube are specified by ydomain; for ydomain$y missing, the default is \( c(\min(y), \max(y)) + c(-1, 1)(\max(y) - \min(y))*.05 \).

On a 1-D interval, the quadrature is the 200-point Gauss-Legendre formula returned from gauss.quad. For multiple numerical vectors, delayed Smolyak cubatures from smolyak.quad are used on cubes with the marginals properly transformed; see Gu and Wang (2003) for the marginal transformations.

The results may vary from run to run. For consistency, specify id.basis or set seed.

For reasonable execution time in high dimensions, set skip.iter=TRUE.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


Examples

data(penny); set.seed(5732)
fit <- sscden1(~year*mil,~mil,data=penny, ydomain=data.frame(mil=c(49,61)))
yy <- 1944+(0:92)/2
quan <- qsscden(fit,c(.05,.25,.5,.75,.95), data.frame(year=yy))
plot(penny$year+.1*rnorm(90),penny$mil,ylim=c(49,61))
for (i in 1:5) lines(yy,quan[,i])
## Clean up
## Not run: rm(penny,yy,quan)

sscoup

Estimating Copula Density Using Smoothing Splines

Description

Estimate copula densities using tensor-product cubic splines.

Usage

sscoup(x, symmetry=FALSE, alpha=1.4, order=NULL, exclude=NULL, weights=NULL, id.basis=NULL, nbasis=NULL, seed=NULL, qdsz.depth=NULL, prec=1e-7, maxiter=30, skip.iter=dim(x)[2]!=2)
sscoup2(x, censoring=NULL, truncation=NULL, symmetry=FALSE, alpha=1.4, weights=NULL, id.basis=NULL, nbasis=NULL, seed=NULL, prec=1e-7, maxiter=30)

Arguments

x Matrix of observations on unit cubes.
symmetry Flag indicating whether to enforce symmetry, or invariance under coordinate permutation.
order Highest order of interaction terms in log density. When NULL, it is set to dim(x)[2] internally.
exclude Pair(s) of marginals whose interactions to be excluded in log density.
alpa Parameter defining cross-validation score for smoothing parameter selection.
weights Optional vector of bin-counts for histogram data.
id.basis Index of observations to be used as "knots."
nbasis Number of "knots" to be used. Ignored when id.basis is specified.
seed Seed to be used for the random generation of "knots." Ignored when id.basis is specified.
qdsz.depth Depth to be used in smolyak.quad for the generation of quadrature.
sscoup

pre

Precision requirement for internal iterations.

maxiter

Maximum number of iterations allowed for internal iterations.

skip.iter

Flag indicating whether to use initial values of theta and skip theta iteration. See ssanova for notes on skipping theta iteration.

censoring

Optional censoring indicator.

truncation

Optional truncation points.

Details

sscoup is essentially ssden applied to observations on unit cubes. Instead of variables in data frames, the data are entered as a numerical matrix, and model complexity is globally controlled by the highest order of interactions allowed in log density.

sscoup2 further restricts the domain to the unit square, but allows for possible censoring and truncation. With censoring=0, 1, 2, 3, a data point \((x_1, x_2)\) represents exact observation, \([0, x_1]\times [0, x_2]\), \([0, x_1]\times [0, x_2]\), \([0, x_1]\times [0, x_2]\), or \([0, x_1]\times [0, x_2]\). With truncation point \((t_1, t_2)\), the sample is taken from \([0, t_1]\times [0, t_2]\) instead of the unit square.

With symmetry=TRUE, one may enforce the interchangeability of coordinates so that \(f(x_1, x_2) = f(x_2, x_1)\), say.

When \((1, 2)\) is a row in exclude, interaction terms involving coordinates 1 and 2 are excluded.

Value

sscoup and sscoup2 return a list object of class "sscopu". dsscopu can be used to evaluate the estimated copula density. A "copularization" process is applied to the estimated density by default so the resulting marginal densities are guaranteed to be uniform.

cdsscopu, cpsscopu, and cqsscopu can be used to evaluate 1-D conditional pdf, cdf, and quantiles.

Note

For reasonable execution time in higher dimensions, set skip.iter=TRUE in calls to sscoup.

When "Newton iteration diverges" in sscoup, try to use a larger qdsz.depth; the default values for dimensions 2, 3, 4, 5, 6+ are 24, 14, 12, 11, 10. To be sure a larger qdsz.depth indeed makes difference, verify the cubature size using smolyak.size.

The results may vary from run to run. For consistency, specify id.basis or set seed.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


Examples

```r
## simulate 2-D data
x <- matrix(runif(200),100,2)
## fit copula density
fit <- sscopu(x)
## "same fit"
fit2 <- sscopu2(x,id=fit$id)
## symmetric fit
fit.s <- sscopu(x,sym=TRUE,id=fit$id)
## Kendall's tau and Spearman's rho
summary(fit); summary(fit2); summary(fit.s)
## clean up
## Not run: rm(x,fit,fit2,fit.s)
```

**Description**

Estimate relative risk using smoothing spline ANOVA models. The symbolic model specification via `formula` follows the same rules as in `lm`, but with the response of a special form.

**Usage**

```r
sscox(formula, type=NULL, data=list(), weights=NULL, subset, na.action=na.omit, partial=NULL, alpha=1.4, id.basis=NULL, nbasis=NULL, seed=NULL, random=NULL, prec=1e-7, maxiter=30, skip.iter=FALSE)
```

**Arguments**

- `formula`: Symbolic description of the model to be fit, where the response is of the form `Surv(futime,status,start=0)`.
- `type`: List specifying the type of spline for each variable. See `mkterm` for details.
- `data`: Optional data frame containing the variables in the model.
- `weights`: Optional vector of counts for duplicated data.
- `subset`: Optional vector specifying a subset of observations to be used in the fitting process.
- `na.action`: Function which indicates what should happen when the data contain NAs.
- `partial`: Optional symbolic description of parametric terms in partial spline models.
- `alpha`: Parameter defining cross-validation score for smoothing parameter selection.
- `id.basis`: Index of observations to be used as "knots."
- `nbasis`: Number of "knots" to be used. Ignored when `id.basis` is specified.
- `seed`: Seed to be used for the random generation of "knots." Ignored when `id.basis` is specified.
random  Input for parametric random effects (frailty) in nonparametric mixed-effect models. See mkran for details.
prec  Precision requirement for internal iterations.
maxiter  Maximum number of iterations allowed for internal iterations.
skip.iter  Flag indicating whether to use initial values of theta and skip theta iteration. See ssanova for notes on skipping theta iteration.

Details
A proportional hazard model is assumed, and the relative risk is estimated via penalized partial likelihood. The model specification via formula is for the log relative risk. For example, Suve(t,d)~u*v prescribes a model of the form

\[ \log f(u,v) = g_u(u) + g_v(v) + g_{u,v}(u,v) \]

with the terms denoted by "u", "v", and "u:v"; relative risk is defined only up to a multiplicative constant, so the constant term is not included in the model.

sscox takes standard right-censored lifetime data, with possible left-truncation and covariates; in Surv(futime,status,start=0)~..., futime is the follow-up time, status is the censoring indicator, and start is the optional left-truncation time.

Parallel to those in a ssanova object, the model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

The selection of smoothing parameters is through a cross-validation mechanism designed for density estimation under biased sampling, with a fudge factor alpha; alpha=1 is "unbiased" for the minimization of Kullback-Leibler loss but may yield severe undersmoothing, whereas larger alpha yields smoother estimates.

A subset of the observations are selected as "knots." Unless specified via id.basis or nbasis, the number of "knots" q is determined by \( \max(30, 10n^{2/9}) \), which is appropriate for the default cubic splines for numerical vectors.

Value
sscox returns a list object of class "sscox".

The method predict.sscox can be used to evaluate the fits at arbitrary points along with standard errors. The method project.sscox can be used to calculate the Kullback-Leibler projection for model selection.

Note
The function Surv(futime,status,start=0) is defined and parsed inside sscox, not quite the same as the one in the survival package. The estimation is invariant of monotone transformations of time.

The results may vary from run to run. For consistency, specify id.basis or set seed.

Author(s)
Chong Gu, <chong@stat.purdue.edu>
References


Examples

```r
## Relative Risk
data(stan)
fit.rr <- sscox(Surv(futime,status)~age,data=stan)
est.rr <- predict(fit.rr,data.frame(age=c(35,40)),se=TRUE)
## Base Hazard
risk <- predict(fit.rr,stan)
fit.bh <- sshzd(Surv(futime,status)~futime,data=stan,offset=log(risk))
tt <- seq(0,max(stan$futime),length=51)
est.bh <- hzdcurve.sshzd(fit.bh,tt,se=TRUE)
## Clean up
## Not run: rm(stan,fit.rr,est.rr,risk,fit.bh,tt,est.bh)
```

ssden

*Estimating Probability Density Using Smoothing Splines*

Description

Estimate probability densities using smoothing spline ANOVA models. The symbolic model specification via `formula` follows the same rules as in `lm`, but with the response missing.

Usage

```r
ssden(formula, type=NULL, data=list(), alpha=1.4, weights=NULL, subset, na.action=na.omit, id.basis=NULL, nbasis=NULL, domain=as.list(NULL), quad=NULL, qdsz.depth=NULL, bias=NULL, prec=1e-7, maxiter=30, skip.iter=FALSE)
ssden1(formula, type=NULL, data=list(), alpha=1.4, weights=NULL, subset, na.action=na.omit, id.basis=NULL, nbasis=NULL, seed=NULL, domain=as.list(NULL), quad=NULL, prec=1e-7, maxiter=30)
```

Arguments

- `formula`: Symbolic description of the model to be fit.
- `type`: List specifying the type of spline for each variable. See `mkterm` for details.
- `data`: Optional data frame containing the variables in the model.
- `alpha`: Parameter defining cross-validation score for smoothing parameter selection.
- `weights`: Optional vector of bin-counts for histogram data.
subset

Optional vector specifying a subset of observations to be used in the fitting process.

na.action

Function which indicates what should happen when the data contain NAs.

id.basis

Index of observations to be used as "knots."

nbasis

Number of "knots" to be used. Ignored when id.basis is specified.

seed

Seed to be used for the random generation of "knots." Ignored when id.basis is specified.

domain

Data frame specifying marginal support of density.

quad

Quadrature for calculating integral. Mandatory if variables other than factors or numerical vectors are involved.

qdsz.depth

Depth to be used in smolyak_quad for the generation of quadrature.

bias

Input for sampling bias.

prec

Precision requirement for internal iterations.

maxiter

Maximum number of iterations allowed for internal iterations.

skip.iter

Flag indicating whether to use initial values of theta and skip theta iteration. See ssanova for notes on skipping theta iteration.

Details

The model specification via formula is for the log density. For example, ~x1*x2 prescribes a model of the form

$log f(x_1, x_2) = g_1(x_1) + g_2(x_2) + g_{12}(x_1, x_2) + C$

with the terms denoted by "x1", "x2", and "x1:x2"; the constant is determined by the fact that a density integrates to one.

The selective term elimination may characterize (conditional) independence structures between variables. For example, ~x1*x2+x1*x3 yields the conditional independence of x2 and x3 given x1.

Parallel to those in a ssanova object, the model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

The selection of smoothing parameters is through a cross-validation mechanism described in the references, with a parameter alpha; alpha=1 is "unbiased" for the minimization of Kullback-Leibler loss but may yield severe undersmoothing, whereas larger alpha yields smoother estimates.

A subset of the observations are selected as "knots." Unless specified via id.basis or nbasis, the number of "knots" q is determined by $max(30, 10n^{2/9})$, which is appropriate for the default cubic splines for numerical vectors.

Value

ssden returns a list object of class "ssden". ssden1 returns a list object of class c("ssden1","ssden"). dssden and cdssden can be used to evaluate the estimated joint density and conditional density; pssden, qssden, cpssden, and cqssden can be used to evaluate (conditional) cdf and quantiles.

The method project.ssden can be used to calculate the Kullback-Leibler projection of "ssden" objects for model selection; project.ssden1 can be used to calculate the square error projection of "ssden1" objects.
**ssden**

**Note**

In ssden, default quadrature will be constructed for numerical vectors on a hyper cube, then outer product with factor levels will be taken if factors are involved. The sides of the hyper cube are specified by `domain`; for `domain$x` missing, the default is \( c(\min(x), \max(x)) + c(-1,1) \times (\max(x) - \min(x)) \times .05 \). In 1-D, the quadrature is the 200-point Gauss-Legendre formula returned from `gauss.quad`. In multi-D, delayed Smolyak cubatures from `smolyak.quad` are used on cubes with the marginals properly transformed; see Gu and Wang (2003) for the marginal transformations.

For reasonable execution time in higher dimensions, set `skip.iter=TRUE` in call to `ssden`. If you get an error message from `ssden` stating "Newton iteration diverges", try to use a larger `qdsz.depth` which will execute slower, or switch to `ssden1`. The default values of `qdsz.depth` for dimensions 4, 5, 6+ are 12, 11, 10.

`ssden1` does not involve multi-D quadrature but does not perform as well as `ssden`. It can be used in very high dimensions where `ssden` is infeasible.

The results may vary from run to run. For consistency, specify `id.basis` or set `seed`.

**Author(s)**

Chong Gu, <chong@stat.purdue.edu>

**References**


**Examples**

```r
## 1-D estimate: Buffalo snowfall
data(buffalo)
buff.fit <- ssden(~buffalo,domain=data.frame(buffalo=c(0,150)))
plot(xx<-seq(0,150,len=101),dssden(buff.fit,xx),type="l")
plot(xx,pssden(buff.fit,xx),type="l")
plot(qq<-seq(0,1,len=51),qssden(buff.fit,qq),type="l")
## Clean up
## Not run: rm(buffalo,buff.fit,xx,qq)
dev.off()
## End(Not run)

## 2-D with triangular domain: AIDS incubation
data(aids)
## rectangular quadrature
quad.pt <- expand.grid(incu=(1:40)-.5)/40*100, infe=((1:40)-.5)/40*100
quad.pt <- quad.pt[quad.pt$incu<=quad.pt$infe,]
quad.wt <- rep(1,nrow(quad.pt))
```
quad.wt[quad.pt$incu==quad.pt$infe] <- .5
quad.wt <- quad.wt/sum(quad.wt)*5e3

## additive model (pre-truncation independence)
aids.fit <- ssden(~incu+infe, data=aids, subset=age>=60,
     domain=data.frame(incu=c(0,100), infe=c(0,100)),
     quad=list(pt=quad.pt, wt=quad.wt))

## conditional (marginal) density of infe
jk <- cdssden(aids.fit, xx<-seq(0,100,len=51), data.frame(incu=50))
plot(xx, jk$pdf, type="l")

## conditional (marginal) quantiles of infe (TIME-CONSUMING)
## Not run:
cqssden(aids.fit, c(.05,.25,.5,.75,.95), data.frame(incu=50))

## End(Not run)
## Clean up
## Not run: rm(aids, quad.pt, quad.wt, aids.fit, jk, xx)
dev.off()
## End(Not run)

## One factor plus one vector
data(gastric)

gastric$trt

fit <- ssden(~futime*trt, data=gastric)

## conditional density
cdssden(fit, c("1","2"), cond=data.frame(futime=150))

## conditional quantiles
cqssden(fit, c(.05,.25,.5,.75,.95), data.frame(trt=as.factor("1")))

## Clean up
## Not run: rm(gastric, fit)

## Sampling bias
## (X,T) is truncated to T<X<1 for T~U(0,1), so X is length-biased
rbias <- function(n) {
  t <- runif(n)
  x <- rnorm(n,.5,.15)
  ok <- (x>t)&(x<1)
  while(m<-sum(!ok)) {
    t[!ok] <- runif(m)
    x[!ok] <- rnorm(m,.5,.15)
    ok <- (x>t)&(x<1)
  }
  cbind(x, t)
}

xt <- rbias(100)
x <- xt[,1]; t <- xt[,2]

## length-biased
bias1 <- list(t=1, wt=1, fun=function(t, x){x[1,]})
fit1 <- ssden(~x, domain=list(x=c(0,1)), bias=bias1)
plot(xx=seq(0,1,len=101), dssden(fit1, xx), type="l")

## truncated
bias2 <- list(t=t, wt=rep(1/100, 100), fun=function(t, x){x[1,]>t})
fit2 <- ssden(~x, domain=list(x=c(0,1)), bias=bias2)
plot(xx, dssden(fit2, xx), type="l")
## Clean up
## Not run: rm(rbias, xt, x, t, bias1, fit1, bias2, fit2)

### sshzd

#### Estimating Hazard Function Using Smoothing Splines

**Description**

Estimate hazard function using smoothing spline ANOVA models. The symbolic model specification via formula follows the same rules as in `lm`, but with the response of a special form.

**Usage**

```r
sshzd(formula, type=NULL, data=list(), alpha=1.4, weights=NULL, subset, offset, na.action=na.omit, partial=NULL, id.basis=NULL, nbasis=NULL, seed=NULL, random=NULL, prec=1e-7, maxiter=30, skip.iter=FALSE)

sshzd1(formula, type=NULL, data=list(), alpha=1.4, weights=NULL, subset, na.action=na.omit, rho="marginal", partial=NULL, id.basis=NULL, nbasis=NULL, seed=NULL, random=NULL, prec=1e-7, maxiter=30, skip.iter=FALSE)
```

**Arguments**

- `formula`: Symbolic description of the model to be fit, where the response is of the form `Surv(futime, status, start=0)`.
- `type`: List specifying the type of spline for each variable. See `mkterm` for details.
- `data`: Optional data frame containing the variables in the model.
- `alpha`: Parameter defining cross-validation score for smoothing parameter selection.
- `weights`: Optional vector of counts for duplicated data.
- `subset`: Optional vector specifying a subset of observations to be used in the fitting process.
- `offset`: Optional offset term with known parameter 1.
- `na.action`: Function which indicates what should happen when the data contain NAs.
- `partial`: Optional symbolic description of parametric terms in partial spline models.
- `id.basis`: Index of observations to be used as "knots."
- `nbasis`: Number of "knots" to be used. Ignored when `id.basis` is specified.
- `seed`: Seed to be used for the random generation of "knots." Ignored when `id.basis` is specified.
- `random`: Input for parametric random effects (frailty) in nonparametric mixed-effect models. See `mkran` for details.
- `prec`: Precision requirement for internal iterations.
maxiter  Maximum number of iterations allowed for internal iterations.
skip.iter  Flag indicating whether to use initial values of theta and skip theta iteration. See ssanova for notes on skipping theta iteration.
rho  Choice of rho function for sshzd1: "marginal" or "weibull".

Details
The model specification via formula is for the log hazard. For example, Suve(t,d)~t*u prescribes a model of the form

\[ \log f(t, u) = C + g_t(t) + g_u(u) + g_{t,u}(t, u) \]

with the terms denoted by "1", "t", "u", and "t:u". Replacing t*u by t+u in the formula, one gets a proportional hazard model with \( g_{t,u} = 0 \).

sshzd takes standard right-censored lifetime data, with possible left-truncation and covariates; in Surv(futime,status,start=0)~..., futime is the follow-up time, status is the censoring indicator, and start is the optional left-truncation time. The main effect of futime must appear in the model terms specified via ... . Parallel to those in a ssanova object, the model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

The selection of smoothing parameters is through a cross-validation mechanism described in Gu (2002, Sec. 7.2), with a parameter alpha; alpha=1 is "unbiased" for the minimization of Kullback-Leibler loss but may yield severe undersmoothing, whereas larger alpha yields smoother estimates.

A subset of the observations are selected as "knots." Unless specified via id.basis or nbasis, the number of "knots" \( q \) is determined by \( \max(30, 10n^{2/9}) \), which is appropriate for the default cubic splines for numerical vectors.

Value
sshzd returns a list object of class "sshzd". sshzd1 returns a list object of class c("sshzd1","sshzd").

hzdrate.sshzd can be used to evaluate the estimated hazard function. hzdcurve.sshzd can be used to evaluate hazard curves with fixed covariates. survexp.sshzd can be used to calculate estimated expected survival.

The method project.sshzd can be used to calculate the Kullback-Leibler projection of "sshzd" objects for model selection; project.sshzd1 can be used to calculate the square error projection of "sshzd1" objects.

Note
The function Surv(futime,status,start=0) is defined and parsed inside sshzd, not quite the same as the one in the survival package.

Integration on the time axis is done by the 200-point Gauss-Legendre formula on c(min(start),max(futime)), returned from gauss.quad.

sshzd1 can be up to 50 times faster than sshzd, at the cost of performance degradation.
The results may vary from run to run. For consistency, specify id.basis or set seed.
Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


Examples

```r
## Model with interaction
data(gastric)
gastric.fit <- sshzd(Surv(futime,status)~futime*trt, data=gastric)
## exp(-Lambda(600)), exp(-(Lambda(1200)-Lambda(600))), and exp(-Lambda(1200))
survexp.sshzd(gastric.fit,c(600,1200,1200),data.frame(trt=as.factor(1)),c(0,600,0))
## Clean up
## Not run: rm(gastric,gastric.fit)
dev.off()
## End(Not run)

## THE FOLLOWING EXAMPLE IS TIME-CONSUMING
## Proportional hazard model
## Not run:
data(stan)
stan.fit <- sshzd(Surv(futime,status)~futime+age, data=stan)
## Evaluate fitted hazard
hzdrate.sshzd(stan.fit, data.frame(futime=c(10,20), age=c(20,30)))
## Plot lambda(t,age=20)
eps <- seq(0,60,leng=101)
hh <- hzdcurve.sshzd(stan.fit,eps, data.frame(age=20))
plot(eps,hh,type="l")
## Clean up
rm(stan,stan.fit,eps,hh)
dev.off()
## End(Not run)
```
sshzd2d  

Estimating 2-D Hazard Function Using Smoothing Splines

Description

Estimate 2-D hazard function using smoothing spline ANOVA models.

Usage

sshzd2d(formula1, formula2, symmetry=FALSE, data, alpha=1.4, weights=NULL, subset=NULL, id.basis=NULL, nbasis=NULL, seed=NULL, prec=1e-7, maxiter=30, skip.iter=FALSE)

sshzd2d1(formula1, formula2, symmetry=FALSE, data, alpha=1.4, weights=NULL, subset=NULL, rho="marginal", id.basis=NULL, nbasis=NULL, seed=NULL, prec=1e-7, maxiter=30, skip.iter=FALSE)

Arguments

formula1  Description of the hazard model to be fit on the first axis.
formula2  Description of the hazard model to be fit on the second axis.
symmetry  Flag indicating whether to enforce symmetry of the two axes.
data  Data frame containing the variables in the model.
alpha  Parameter defining cross-validation scores for smoothing parameter selection.
weights  Optional vector of counts for duplicated data.
subset  Optional vector specifying a subset of observations to be used in the fitting process.
id.basis  Index of observations to be used as "knots."
nbasis  Number of "knots" to be used. Ignored when id.basis is specified.
seed  Seed to be used for the random generation of "knots." Ignored when id.basis is specified.
prec  Precision requirement for internal iterations.
maxiter  Maximum number of iterations allowed for internal iterations.
skip.iter  Flag indicating whether to use initial values of theta and skip theta iteration in marginal hazard estimation.
rho  Choice of rho function for sshzd2d1: "marginal" or "weibull".
Details

The 2-D survival function is expressed as \( S(t_1, t_2) = C(S_1(t_1), S_2(t_2)), \) where \( S_1(t_1), S_2(t_2) \) are marginal survival functions and \( C(u_1, u_2) \) is a 2-D copula. The marginal survival functions are estimated via the marginal hazards as in sshzd, and the copula is estimated nonparametrically by calling sscopu2.

When symmetry=TRUE, a common marginal survival function \( S_1(t)=S_2(t) \) is estimated, and a symmetric copula is estimated such that \( C(u_1, u_2) = C(u_2, u_1). \)

Covariates can be incorporated in the marginal hazard models as in sshzd, including parametric terms via partial and frailty terms via random. Arguments formula1 and formula2 are typically model formulas of the same form as the argument formula in sshzd, but when partial or random are needed, formula1 and formula2 should be lists with model formulas as the first elements and partial/random as named elements; when necessary, variable configurations (that are done via argument type in sshzd) should also be entered as named elements of lists formula1/formula2.

When symmetry=TRUE, parallel model formulas must be consistent of each other, such as

```r
formula1=list(Surv(t1,d1)~t1*u1,partial=~z1,random=~1|id1)
formula2=list(Surv(t2,d2)~t2*u2,partial=~z2,random=~1|id2)
```

where pairs t1-t2, d2-d2 respectively are different elements in data, pairs u1-u2, z1-z2 respectively may or may not be different elements in data, and factors id1 and id2 are typically the same but at least should have the same levels.

Value

sshzd2d and sshzd2d1 return a list object of class "sshzd2d".

hzdrate.sshzd2d can be used to evaluate the estimated 2-D hazard function. survexp.sshzd2d can be used to calculate estimated survival functions.

Note

sshzd2d1 executes faster than sshzd2d, but often at the cost of performance degradation.

The results may vary from run to run. For consistency, specify id.basis or set seed.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


Examples

```r
## THE FOLLOWING EXAMPLE IS TIME-CONSUMING
## Not run:
data(DiaRet)
```
## Common proportional hazard model on the margins

```r
fit <- sshzd2d(Surv(time1,status1)~time1+trt1*type,
                Surv(time2,status2)~time2+trt2*type,
                data=DiaRet, symmetry=TRUE)
```

## Evaluate fitted survival and hazard functions

```r
time <- cbind(c(50,70),c(70,70))
cova <- data.frame(trt1=as.factor(c(1,1)),trt2=as.factor(c(1,0)),
                    type=as.factor(c("juvenile","adult")))
surveexp.sshzd2d(fit,time,cov=cova)
hzdrate.sshzd2d(fit,time,cov=cova)
```

## Association between margins: Kendall's tau and Spearman's rho

```r
summary(fit$copu)
```

## Clean up

```r
rm(DiaRet,fit,time,cova)
dev.off()
```

## End(Not run)

---

### ssllrm

**Fitting Smoothing Spline Log-Linear Regression Models**

**Description**

Fit smoothing spline log-linear regression models. The symbolic model specification via `formula` follows the same rules as in `lm`.

**Usage**

```r
ssllrm(formula, response, type=NULL, data=list(), weights, subset,
       na.action=na.omit, alpha=1, id.basis=NULL, nbasis=NULL,
       seed=NULL, random=NULL, prec=1e-7, maxiter=30, skip.iter=FALSE)
```

**Arguments**

- `formula`: Symbolic description of the model to be fit.
- `response`: Formula listing response variables.
- `type`: List specifying the type of spline for each variable. See `mkterm` for details.
- `data`: Optional data frame containing the variables in the model.
- `weights`: Optional vector of weights to be used in the fitting process.
- `subset`: Optional vector specifying a subset of observations to be used in the fitting process.
- `na.action`: Function which indicates what should happen when the data contain NAs.
- `alpha`: Parameter modifying GCV or Mallows' CL; larger absolute values yield smoother fits; negative value invokes a stable and more accurate GCV/CL evaluation algorithm but may take two to five times as long. Ignored when `method="m"` are specified.
### ssllrm

- **id.basis**: Index designating selected "knots".
- **nbasis**: Number of "knots" to be selected. Ignored when `id.basis` is supplied.
- **seed**: Seed to be used for the random generation of "knots". Ignored when `id.basis` is supplied.
- **random**: Input for parametric random effects in nonparametric mixed-effect models. See `mkran` for details.
- **prec**: Precision requirement for internal iterations.
- **maxiter**: Maximum number of iterations allowed for internal iterations.
- **skip.iter**: Flag indicating whether to use initial values of theta and skip theta iteration. See `ssanova` for notes on skipping theta iteration.

### Details

The model is specified via `formula` and `response`, where `response` lists the response variables. For example, `ssllrm(~y1*y2*x, ~y1+y2)` prescribe a model of the form

\[
\log f(y_1, y_2|x) = g_1(y_1) + g_2(y_2) + g_{12}(y_1, y_2) + g_{21}(x, y_1) + g_{22}(x, y_2) + g_{121}(x, y_1, y_2) + C(x)
\]

with the terms denoted by "y1", "y2", "y1:y2", "y1:x", "y2:x", and "y1:y2:x"; the term(s) not involving response(s) are removed and the constant C(x) is determined by the fact that a conditional density integrates (adds) to one on the y axis.

The model terms are sums of unpenalized and penalized terms. Attached to every penalized term there is a smoothing parameter, and the model complexity is largely determined by the number of smoothing parameters.

A subset of the observations are selected as "knots." Unless specified via `id.basis` or `nbasis`, the number of "knots" q is determined by \( \max(30, 10n^{2/9}) \), which is appropriate for the default cubic splines for numerical vectors.

### Value

`ssllrm` returns a list object of class "ssllrm".

The method `predict.ssllrm` can be used to evaluate \( f(y|x) \) at arbitrary x, or contrasts of \( \log f(y|x) \) such as the odds ratio along with standard errors. The method `project.ssllrm` can be used to calculate the Kullback-Leibler projection for model selection.

### Note

The responses, or y-variables, must be factors, and there must be at least one numerical x’s. For `response`, there is no difference between ~y1+y2 and ~y1*y2.

The results may vary from run to run. For consistency, specify `id.basis` or set `seed`.

### Author(s)

Chong Gu, <chong@stat.purdue.edu>
References


Examples

```r
## Simulate data
x <- function(x)
    {.3*(1e6*(x^11*(1-x)^6)+1e4*(x^3*(1-x)^10))-2}
x <- (0:100)/100
p <- 1-1/(1+exp(test(x)))
y <- rbinom(x,3,p)
y1 <- as.ordered(y)
y2 <- as.factor(rbinom(x,1,p))
## Fit model
fit <- ssllrm(~y1*y2*x,~y1+y2)
## Evaluate f(y|x)
est <- predict(fit,data.frame(x=x),
data.frame(y1=as.factor(0:3),y2=as.factor(rep(0,4))))
## f(y|x) at all y values (fit$qd.pt)
est <- predict(fit,data.frame(x=x))
## Evaluate contrast of log f(y|x)
est <- predict(fit,data.frame(x=x),odds=c(-1,.5,.5,0),
data.frame(y1=as.factor(0:3),y2=as.factor(rep(0,4))),se=TRUE)
## Odds ratio log{f(0,0|x)/f(3,0|x)}
est <- predict(fit,data.frame(x=x),odds=c(1,-1),
data.frame(y1=as.factor(c(0,3)),y2=as.factor(c(0,1))),se=TRUE)
## KL projection
kl <- project(fit,include=c("y2:x","y1:y2","y1:x","y2:x"))
## Clean up
## Not run: rm(test,x,p,y,y1,y2,fit,est,kl)
dev.off()
## End(Not run)
```

stan

Stanford Heart Transplant Data

Description

Survival of patients from the Stanford heart transplant program.

Usage

data(stan)
Format

A data frame containing 184 observations on the following variables.

- **time**: Follow-up time after transplant, in days.
- **status**: Censoring status.
- **age**: Age at transplant.
- **futime**: Square root of time.

Source


---

**summary.gssanova**

Assessing Smoothing Spline ANOVA Fits with Non-Gaussian Responses

Description

Calculate various summaries of smoothing spline ANOVA fits with non-Gaussian responses.

Usage

```r
## S3 method for class 'gssanova'
summary(object, diagnostics=FALSE, ...)
```

Arguments

- **object**: Object of class "gssanova".
- **diagnostics**: Flag indicating if diagnostics are required.
- **...**: Ignored.

Details

Similar to the iterated weighted least squares fitting of `glm`, penalized likelihood regression fit can be calculated through iterated penalized weighted least squares.

The diagnostics are based on the "pseudo" Gaussian response model behind the weighted least squares problem at convergence.

Value

`summary.gssanova` returns a list object of class "summary.gssanova" consisting of the following components. The entries pi, kappa, cosines, and roughness are only calculated if diagnostics=TRUE.

- **call**: Fitting call.
- **family**: Error distribution.
- **alpha**: Parameter used to define cross-validation in model fitting.
Summary of Smoothing Spline ANOVA Fits with Non-Gaussian Responses

Calculate various summaries of smoothing spline ANOVA fits with non-Gaussian responses.

**Usage**

```r
## S3 method for class 'gssanova'
summary(object, diagnostics=FALSE, ...)
```

**Arguments**

- `object`: Object of class "gssanova".
- `diagnostics`: Flag indicating if diagnostics are required.
- `...`: Ignored.

**Author(s)**

Chong Gu, `<chong@stat.purdue.edu>`

**References**


**See Also**

Fitting function `gssanova` and methods `predict.ssanova`, `project.gssanova`, `fitted.gssanova`.

---

**Description**

Calculate various summaries of smoothing spline ANOVA fits with non-Gaussian responses.
Details

Similar to the iterated weighted least squares fitting of glm, penalized likelihood regression fit can be calculated through iterated penalized weighted least squares.

The diagnostics are based on the "pseudo" Gaussian response model behind the weighted least squares problem at convergence.

Value

summary.gssanova0 returns a list object of class "summary.gssanova0" consisting of the following components. The entries pi, kappa, cosines, and roughness are only calculated if diagnostics=TRUE.

call     Fitting call.
family   Error distribution.
method   Method for smoothing parameter selection.
dispersion Assumed or estimated dispersion parameter.
iter     Number of performance-oriented iterations performed.
fitted   Fitted values on the link scale.
residuals Working residuals on the link scale.
rss      Residual sum of squares.
dev.resid Deviance residuals.
deviance  Deviance of the fit.
dev.null  Deviance of the null model.
alpha    Estimated size for family="nbinomial" with one column responses. Estimated inverse scale of log life time for family="nbinomial", "lognorm", or "loglogis".
penalty  Roughness penalty associated with the fit.
pi       "Percentage decomposition" of "explained variance" into model terms.
kappa    Concurvity diagnostics for model terms. Virtually the square roots of variance inflation factors of a retrospective linear model.
cosines  Cosine diagnostics for practical significance of model terms.
roughness Percentage decomposition of the roughness penalty penalty into model terms.

Author(s)

Chong Gu, <chong@stat.purdue.edu>

References


See Also

Fitting function gssanova0 and methods predict.ssanova0, fitted.gssanova.
summary.ssanova  Assessing Smoothing Spline ANOVA Fits

Description
Calculate various summaries of smoothing spline ANOVA fits.

Usage
## S3 method for class 'ssanova'
summary(object, diagnostics=FALSE, ...)
## S3 method for class 'ssanova0'
summary(object, diagnostics=FALSE, ...)
## S3 method for class 'ssanova9'
summary(object, diagnostics=FALSE, ...)

Arguments
object Object of class "ssanova".
diagnostics Flag indicating if diagnostics are required.
... Ignored.

Value
summary.ssanova returns a list object of class "summary.ssanova" consisting of the following components. The entries pi, kappa, cosines, and roughness are only calculated if diagnostics=TRUE; see the reference below for details concerning the diagnostics.

call Fitting call.
method Method for smoothing parameter selection.
fitted Fitted values.
residuals Residuals.
sigma Assumed or estimated error standard deviation.
r.squared Fraction of "explained variance" by the fitted model.
rss Residual sum of squares.
penalty Roughness penalty associated with the fit.
pi "Percentage decomposition" of "explained variance" into model terms.
kappa Concurvity diagnostics for model terms. Virtually the square roots of variance inflation factors of a retrospective linear model.
cosines Cosine diagnostics for practical significance of model terms.
roughness Percentage decomposition of the roughness penalty penalty into model terms.

Author(s)
Chong Gu, <chong@stat.purdue.edu>
References


See Also

Fitting functions `ssanova, ssanova0` and methods `predict.ssanova, project.ssanova, fitted.ssanova`.

---

### summary.sscopu

**Calculating Kendall’s Tau and Spearman’s Rho for 2-D Copula Density Estimates**

**Description**

Calculate Kendall’s tau and Spearman’s rho for 2-D copula density estimates.

**Usage**

```r
## S3 method for class 'sscopu'
summary(object, ...)
```

**Arguments**

- `object`: Object of class "sscopu".
- `...`: Ignored.

**Value**

A list containing Kendall’s tau and Spearman’s rho.

**See Also**

Fitting functions `sscopu` and `sscopu2`.

---

### wesdr

**Progression of Diabetic Retinopathy**

**Description**

Data derived from the Wisconsin Epidemiological Study of Diabetic Retinopathy.

**Usage**

```r
data(wesdr)
```

**Format**

A data frame containing 669 observations on the following variables.
**Source**


**References**


# Index

**Topic** datasets
- aids, 2
- bacteriuria, 3
- buffalo, 4
- clim, 7
- ColoCan, 7
- DiaRet, 8
- esc, 12
- eyetrack, 12
- gastric, 14
- LakeAcidity, 23
- NO2, 24
- nox, 25
- ozone, 26
- penny, 26
- Sachs, 34
- stan, 60
- wesdr, 65

**Topic** distribution
- cdsddcden, 4
- cdsdscopu, 5
- cdsdden, 6
- dsscden, 9
- dssscopu, 10
- dssden, 11
- fitted.ssanova, 13
- gssanova, 15
- gssanova0, 18
- hzdrate.sshzd, 21
- hzdrate.sshzd2d, 22
- predict.ssanova, 27
- predict.ssccox, 29
- predict.ssslrm, 30
- print, 31
- project, 32
- ssanova, 35
- ssanova0, 38
- ssanova9, 40
- sscden, 43
- sscopu, 45
- sscox, 47
- ssden, 49
- sshzd, 53
- sshzd2d, 56
- ssslrm, 58
- summary.gssanova, 61
- summary.gssanova0, 62
- summary.ssanova, 64
- summary.sscopu, 65

**Topic** regression
- fitted.ssanova, 13
- gssanova, 15
- gssanova0, 18
- predict.ssanova, 27
- predict.ssccox, 29
- predict.ssslrm, 30
- ssanova, 35
- ssanova0, 38
- ssanova9, 40
- ssslrm, 58
- summary.gssanova, 61

**Topic** htest
- project, 32

**Topic** math
- gauss.quad, 14
- nlm0, 24
- smolyak, 34

**Topic** models
- cdsddcden, 4
- cdsdscopu, 5
- cdsdden, 6
INDEX

summary.gssanova0, 62
summary.ssanova, 64

*Topic smooth
  cdsscden, 4
  cdsscopu, 5
  cdssden, 6
  dsscden, 9
  dsscopu, 10
dssden, 11
fitted.ssanova, 13
gssanova, 15
gssanova0, 18
hzdrate.sshzd, 21
hzdrate.sshzd2d, 22
predict.ssanova, 27
predict.sscox, 29
predict.sslrm, 30
print, 31
project, 32
ssanova, 35
ssanova0, 38
ssanova9, 40
sscden, 43
sscopu, 45
sscox, 47
ssden, 49
sshzd, 53
sshzd2d, 56
sslrm, 58
summary.gssanova, 61
summary.gssanova0, 62
summary.ssanova, 64
summary.sscopu, 65

*Topic survival
  hzdrate.sshzd, 21
  hzdrate.sshzd2d, 22
  predict.sscox, 29
  sscox, 47
  sshzd, 53
  sshzd2d, 56

aids, 2
bacteriuria, 3
buffalo, 4
cdsscden, 4, 10, 44
cdsscopu, 5, 46
cdssden, 6, 11, 50
class, 61, 63, 64
clim, 7
ColoCan, 7
cpsscden, 44
cpsscden (cdsscden), 4
cpsscopu, 46
cpsscopu (cdsscopu), 5
cpssden, 50
cpssden (cdssden), 6
cpsscden, 44
cpsscden (cdsscden), 4
cpsscopu, 46
cpsscopu (cdsscopu), 5
cpssden, 50
cpssden (cdssden), 6
d.sscden (dsscden), 9
d.sscden (dsscden), 9
d.ssdns (dssden), 11
d.ssdns (dssden), 11
DiaRet, 8
dsscden, 5, 9, 44
dsscopu, 6, 10, 46
dssden, 7, 11, 50
esc, 12
eyetrack, 12
fitted.gssanova, 16, 19, 62, 63
fitted.gssanova (fitted.ssanova), 13
fitted.ssanova, 13, 28, 36, 39, 41, 65
gastric, 14
gauss.quad, 14, 44, 51, 54
glm, 15, 16, 18, 20, 61, 63
gssanova, 15, 20, 28, 32, 34, 62
gssanova0, 16, 18, 20, 28, 32, 63
gssanova1, 20
gssanova1 (gssanova0), 18
hzdcurve.sshzd, 54
hzdcurve.sshzd (hzdrate.sshzd), 21
hzdrate.sshzd, 21, 54
hzdrate.sshzd2d, 22, 57
LakeAcidity, 23
lm, 15, 18, 35, 38, 40, 43, 47, 49, 53, 58
mkcov, 41
mkran, 15, 19, 20, 36, 39, 48, 53, 59
INDEX

mkterm, 15, 18, 35, 38, 40, 43, 47, 49, 53, 58
NegBinomial, 16, 19
nlm, 37, 42
nlm0, 24
NO2, 24
nox, 25
ozone, 26
para.arma (ssanova9), 40
penny, 26
predict.lm, 5, 6, 10, 11
predict.ssanova, 16, 19, 27, 36, 41, 62, 65
predict.ssanova0, 19, 39, 63
predict.ssanova0 (predict.ssanova), 27
predict.sscox, 29, 48
predict.ssllrm, 30, 59
predict1 (predict.ssanova), 27
print, 31
project, 20, 32, 39
project.gssanova, 16, 62
project.ssanova, 28, 36, 65
project.ssanova9, 41
project.sscden, 44
project.sscden1, 44
project.sscox, 30, 48
project.ssden, 50
project.ssden1, 50
project.sshzd, 54
project.sshzd1, 54
project.ssllrm, 59
psscden, 44
psscden (dsscden), 9
pssden, 50
pssden (dssden), 11
qsscden, 44
qsscden (dsscden), 9
qssden, 50
qssden (dssden), 11
residuals.gssanova, 16, 19
residuals.gssanova (fitted.ssanova), 13
residuals.ssanova, 36, 39, 41
residuals.ssanova (fitted.ssanova), 13
Sachs, 34
smolyak, 34
smolyak.quad, 44, 45, 50, 51
smolyak.size, 46
ssanova, 15, 19, 28, 32, 34, 35, 39, 43, 46, 48,
50, 54, 59, 65
ssanova0, 19, 28, 32, 36, 37, 38, 41, 65
ssanova9, 40
sscden, 5, 10, 43
sscden1 (sscden), 43
sscopu, 6, 11, 45, 65
sscopu2, 6, 11, 57, 65
sscopu2 (sscopu), 45
sscox, 30, 47
ssden, 7, 11, 32, 34, 46, 49
ssden1 (ssden), 49
sshzd, 22, 32, 34, 53, 57
sshzd1, 34
sshzd1 (sshzd), 53
sshzd2d, 22, 56
sshzd2d1 (sshzd2d), 56
ssllrm, 31, 32, 58
stan, 60
summary.gssanova, 16, 19, 28, 32, 61
summary.gssanova0, 19, 28, 32, 62
summary.ssanova, 28, 32, 36, 64
summary.ssanova0, 39
summary.ssanova0 (summary.ssanova), 64
summary.ssanova9, 41
summary.ssanova9 (summary.ssanova), 64
summary.sscopu, 65
survexp.sshzd, 54
survexp.sshzd (hzdrate.sshzd), 21
survexp.sshzd2d, 57
survexp.sshzd2d (hzdrate.sshzd2d), 22
wesdr, 65