

# Package ‘spatial’

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**Description** Functions for kriging and point pattern analysis.

**Title** Functions for Kriging and Point Pattern Analysis

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**Author** Brian Ripley [aut, cre, cph],  
Roger Bivand [ctb],  
William Venables [cph]

**Maintainer** Brian Ripley <ripley@stats.ox.ac.uk>

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---

anova.trls	<i>Anova tables for fitted trend surface objects</i>
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---

### Description

Compute analysis of variance tables for one or more fitted trend surface model objects; where `anova.trls` is called with multiple objects, it passes on the arguments to `anova.list.trls`.

### Usage

```
## S3 method for class 'trls'
anova(object, ...)
anova.list.trls(object, ...)
```

### Arguments

<code>object</code>	A fitted trend surface model object from <code>surf.ls</code>
<code>...</code>	Further objects of the same kind

### Value

`anova.trls` and `anova.list.trls` return objects corresponding to their printed tabular output.

### References

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

### See Also

[surf.ls](#)

**Examples**

```
library(stats)
data(topo, package="MASS")
topo0 <- surf.ls(0, topo)
topo1 <- surf.ls(1, topo)
topo2 <- surf.ls(2, topo)
topo3 <- surf.ls(3, topo)
topo4 <- surf.ls(4, topo)
anova(topo0, topo1, topo2, topo3, topo4)
summary(topo4)
```

---

correlogram

*Compute Spatial Correlograms*

---

**Description**

Compute spatial correlograms of spatial data or residuals.

**Usage**

```
correlogram(krig, nint, plotit = TRUE, ...)
```

**Arguments**

krig	trend-surface or kriging object with columns x, y, and z
nint	number of bins used
plotit	logical for plotting
...	parameters for the plot

**Details**

Divides range of data into nint bins, and computes the covariance for pairs with separation in each bin, then divides by the variance. Returns results for bins with 6 or more pairs.

**Value**

x and y coordinates of the correlogram, and cnt, the number of pairs averaged per bin.

**Side Effects**

Plots the correlogram if plotit = TRUE.

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.  
Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**[variogram](#)**Examples**

```
data(topo, package="MASS")
topo.kr <- surf.ls(2, topo)
correlogram(topo.kr, 25)
d <- seq(0, 7, 0.1)
lines(d, expcov(d, 0.7))
```

---

expcov

*Spatial Covariance Functions*

---

**Description**

Spatial covariance functions for use with `surf.gls`.

**Usage**

```
expcov(r, d, alpha = 0, se = 1)
gaucov(r, d, alpha = 0, se = 1)
sphercov(r, d, alpha = 0, se = 1, D = 2)
```

**Arguments**

r	vector of distances at which to evaluate the covariance
d	range parameter
alpha	proportion of nugget effect
se	standard deviation at distance zero
D	dimension of spheres.

**Value**

vector of covariance values.

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.  
Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**[surf.gls](#)

**Examples**

```
data(topo, package="MASS")
topo.kr <- surf.ls(2, topo)
correlogram(topo.kr, 25)
d <- seq(0, 7, 0.1)
lines(d, expcov(d, 0.7))
```

Kaver

*Average K-functions from Simulations***Description**

Forms the average of a series of (usually simulated) K-functions.

**Usage**

```
Kaver(fs, nsim, ...)
```

**Arguments**

fs	full scale for K-fn
nsim	number of simulations
...	arguments to simulate one point process object

**Value**

list with components x and y of the average K-fn on L-scale.

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.  
 Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[Kfn](#), [Kenvl](#)

**Examples**

```
towns <- ppinit("towns.dat")
par(pty="s")
plot(Kfn(towns, 40), type="b")
plot(Kfn(towns, 10), type="b", xlab="distance", ylab="L(t)")
for(i in 1:10) lines(Kfn(Psim(69), 10))
lims <- Kenvl(10,100,Psim(69))
lines(lims$x,lims$lower, lty=2, col="green")
lines(lims$x,lims$upper, lty=2, col="green")
lines(Kaver(10,25,Strauss(69,0.5,3.5)), col="red")
```

---

 Kenvl

 Compute Envelope and Average of Simulations of K-fns
 

---

**Description**

Computes envelope (upper and lower limits) and average of simulations of K-fns

**Usage**

```
Kenvl(fs, nsim, ...)
```

**Arguments**

fs	full scale for K-fn
nsim	number of simulations
...	arguments to produce one simulation

**Value**

list with components	
x	distances
lower	min of K-fns
upper	max of K-fns
aver	average of K-fns

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.  
 Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[Kfn](#), [Kaver](#)

**Examples**

```
towns <- ppinit("towns.dat")
par(pty="s")
plot(Kfn(towns, 40), type="b")
plot(Kfn(towns, 10), type="b", xlab="distance", ylab="L(t)")
for(i in 1:10) lines(Kfn(Psim(69), 10))
lims <- Kenvl(10,100,Psim(69))
lines(lims$x,lims$lower, lty=2, col="green")
lines(lims$x,lims$upper, lty=2, col="green")
lines(Kaver(10,25,Strauss(69,0.5,3.5)), col="red")
```

---

Kfn *Compute K-fn of a Point Pattern*

---

**Description**

Actually computes  $L = \sqrt{K/\pi}$ .

**Usage**

```
Kfn(pp, fs, k=100)
```

**Arguments**

pp	a list such as a pp object, including components x and y
fs	full scale of the plot
k	number of regularly spaced distances in (0, fs)

**Details**

relies on the domain D having been set by ppinit or ppreion.

**Value**

A list with components

x	vector of distances
y	vector of L-fn values
k	number of distances returned – may be less than k if fs is too large
dmin	minimum distance between pair of points
lm	maximum deviation from $L(t) = t$

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[ppinit](#), [ppregion](#), [Kaver](#), [Kenvl](#)

**Examples**

```
towns <- ppinit("towns.dat")
par(pty="s")
plot(Kfn(towns, 10), type="s", xlab="distance", ylab="L(t)")
```

---

ppgetregion

*Get Domain for Spatial Point Pattern Analyses*

---

### Description

Retrieves the rectangular domain  $(x1, xu) \times (y1, yu)$  from the underlying C code.

### Usage

```
ppgetregion()
```

### Value

A vector of length four with names `c("x1", "xu", "y1", "yu")`.

### References

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

### See Also

[ppregion](#)

---

ppinit

*Read a Point Process Object from a File*

---

### Description

Read a file in standard format and create a point process object.

### Usage

```
ppinit(file)
```

### Arguments

file                    string giving file name

### Details

The file should contain  
the number of points  
a header (ignored)  
x1 xu y1 yu scale  
x y (repeated n times)



**Value**

class "pp" object with components x, y, x1, xu, y1, yu

**Side Effects**

Calls ppreion to set the domain.

**References**

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[ppregion](#)

**Examples**

```
towns <- ppinit("towns.dat")
par(pty="s")
plot(Kfn(towns, 10), type="b", xlab="distance", ylab="L(t)")
```

---

 pplik

---

*Pseudo-likelihood Estimation of a Strauss Spatial Point Process*


---

**Description**

Pseudo-likelihood estimation of a Strauss spatial point process.

**Usage**

```
pplik(pp, R, ng=50, trace=FALSE)
```

**Arguments**

pp	a pp object
R	the fixed parameter R
ng	use a ng x ng grid with border R in the domain for numerical integration.
trace	logical? Should function evaluations be printed?

**Value**

estimate for c in the interval  $[0, 1]$ .

**References**

Ripley, B. D. (1988) *Statistical Inference for Spatial Processes*. Cambridge.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**[Strauss](#)**Examples**

```
pinet <- ppinit("pinet.dat")
pplik(pinet, 0.7)
```

---

ppregion

*Set Domain for Spatial Point Pattern Analyses*

---

**Description**

Sets the rectangular domain  $(x_l, x_u) \times (y_l, y_u)$ .

**Usage**

```
ppregion(xl = 0, xu = 1, yl = 0, yu = 1)
```

**Arguments**

xl	Either xl or a list containing components xl, xu, yl, yu (such as a point-process object)
xu	
yl	
yu	

**Value**

none

**Side Effects**

initializes variables in the C subroutines.

**References**

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[ppinit](#), [ppgetregion](#)

---

predict.trls                      *Predict method for trend surface fits*

---

## Description

Predicted values based on trend surface model object

## Usage

```
## S3 method for class 'trls'  
predict(object, x, y, ...)
```

## Arguments

object	Fitted trend surface model object returned by <code>surf.ls</code>
x	Vector of prediction location eastings (x coordinates)
y	Vector of prediction location northings (y coordinates)
...	further arguments passed to or from other methods.

## Value

`predict.trls` produces a vector of predictions corresponding to the prediction locations. To display the output with image or contour, use `trmat` or convert the returned vector to matrix form.

## References

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

## See Also

[surf.ls](#), [trmat](#)

## Examples

```
data(topo, package="MASS")  
topo2 <- surf.ls(2, topo)  
topo4 <- surf.ls(4, topo)  
x <- c(1.78, 2.21)  
y <- c(6.15, 6.15)  
z2 <- predict(topo2, x, y)  
z4 <- predict(topo4, x, y)  
cat("2nd order predictions:", z2, "\n4th order predictions:", z4, "\n")
```

---

prmat

*Evaluate Kriging Surface over a Grid*

---

### Description

Evaluate Kriging surface over a grid.

### Usage

```
prmat(obj, x1, xu, y1, yu, n)
```

### Arguments

obj	object returned by <code>surf.gls</code>
x1	limits of the rectangle for grid
xu	
y1	
yu	
n	use $n \times n$ grid within the rectangle

### Value

list with components `x`, `y` and `z` suitable for contour and image.

### References

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

### See Also

[surf.gls](#), [trmat](#), [semat](#)

### Examples

```
data(topo, package="MASS")
topo.kr <- surf.gls(2, expcov, topo, d=0.7)
prsurf <- prmat(topo.kr, 0, 6.5, 0, 6.5, 50)
contour(prsurf, levels=seq(700, 925, 25))
```

**Description**

Simulate Binomial spatial point process.

**Usage**

```
Psim(n)
```

**Arguments**

n                    number of points

**Details**

relies on the region being set by ppinit or ppregion.

**Value**

list of vectors of x and y coordinates.

**Side Effects**

uses the random number generator.

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[SSI](#), [Strauss](#)

**Examples**

```
towns <- ppinit("towns.dat")
par(pty="s")
plot(Kfn(towns, 10), type="s", xlab="distance", ylab="L(t)")
for(i in 1:10) lines(Kfn(Psim(69), 10))
```

---

semat

*Evaluate Kriging Standard Error of Prediction over a Grid*

---

## Description

Evaluate Kriging standard error of prediction over a grid.

## Usage

```
semat(obj, xl, xu, yl, yu, n, se)
```

## Arguments

obj	object returned by <code>surf.gls</code>
xl	limits of the rectangle for grid
xu	
yl	
yu	
n	use $n \times n$ grid within the rectangle
se	standard error at distance zero as a multiple of the supplied covariance. Otherwise estimated, and it assumed that a correlation function was supplied.

## Value

list with components x, y and z suitable for contour and image.

## References

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.  
Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

## See Also

[surf.gls](#), [trmat](#), [prmat](#)

## Examples

```
data(topo, package="MASS")
topo.kr <- surf.gls(2, expcov, topo, d=0.7)
prsurf <- prmat(topo.kr, 0, 6.5, 0, 6.5, 50)
contour(prsurf, levels=seq(700, 925, 25))
sesurf <- semat(topo.kr, 0, 6.5, 0, 6.5, 30)
contour(sesurf, levels=c(22,25))
```

---

SSI

*Simulates Sequential Spatial Inhibition Point Process*

---

### Description

Simulates SSI (sequential spatial inhibition) point process.

### Usage

```
SSI(n, r)
```

### Arguments

n	number of points
r	inhibition distance

### Details

uses the region set by `ppinit` or `ppregion`.

### Value

list of vectors of x and y coordinates

### Side Effects

uses the random number generator.

### Warnings

will never return if `r` is too large and it cannot place `n` points.

### References

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

### See Also

[Psim](#), [Strauss](#)

### Examples

```
towns <- ppinit("towns.dat")
par(pty = "s")
plot(Kfn(towns, 10), type = "b", xlab = "distance", ylab = "L(t)")
lines(Kaver(10, 25, SSI(69, 1.2)))
```

---

Strauss

*Simulates Strauss Spatial Point Process*

---

### Description

Simulates Strauss spatial point process.

### Usage

```
Strauss(n, c=0, r)
```

### Arguments

n	number of points
c	parameter $c$ in $[0, 1]$ . $c = 0$ corresponds to complete inhibition at distances up to $r$ .
r	inhibition distance

### Details

Uses spatial birth-and-death process for  $4n$  steps, or for  $40n$  steps starting from a binomial pattern on the first call from an other function. Uses the region set by `ppinit` or `ppregion`.

### Value

list of vectors of  $x$  and  $y$  coordinates

### Side Effects

uses the random number generator

### References

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.  
Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

### See Also

[Psim](#), [SSI](#)

### Examples

```
towns <- ppinit("towns.dat")
par(pty="s")
plot(Kfn(towns, 10), type="b", xlab="distance", ylab="L(t)")
lines(Kaver(10, 25, Strauss(69,0.5,3.5)))
```



---

`surf.gls`*Fits a Trend Surface by Generalized Least-squares*

---

**Description**

Fits a trend surface by generalized least-squares.

**Usage**

```
surf.gls(np, covmod, x, y, z, nx = 1000, ...)
```

**Arguments**

<code>np</code>	degree of polynomial surface
<code>covmod</code>	function to evaluate covariance or correlation function
<code>x</code>	x coordinates or a data frame with columns x, y, z
<code>y</code>	y coordinates
<code>z</code>	z coordinates. Will supersede x\$z
<code>nx</code>	Number of bins for table of the covariance. Increasing adds accuracy, and increases size of the object.
<code>...</code>	parameters for covmod

**Value**

list with components

<code>beta</code>	the coefficients
<code>x</code>	
<code>y</code>	
<code>z</code>	and others for internal use only.

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[trmat](#), [surf.ls](#), [prmat](#), [semat](#), [expcov](#), [gaucov](#), [sphercov](#)

**Examples**

```

library(MASS) # for eqscplot
data(topo, package="MASS")
topo.kr <- surf.gls(2, expcov, topo, d=0.7)
trsurf <- trmat(topo.kr, 0, 6.5, 0, 6.5, 50)
eqscplot(trsurf, type = "n")
contour(trsurf, add = TRUE)

prsurf <- prmat(topo.kr, 0, 6.5, 0, 6.5, 50)
contour(prsurf, levels=seq(700, 925, 25))
sesurf <- semat(topo.kr, 0, 6.5, 0, 6.5, 30)
eqscplot(sesurf, type = "n")
contour(sesurf, levels = c(22, 25), add = TRUE)

```

surf.ls

*Fits a Trend Surface by Least-squares***Description**

Fits a trend surface by least-squares.

**Usage**

```
surf.ls(np, x, y, z)
```

**Arguments**

np	degree of polynomial surface
x	x coordinates or a data frame with columns x, y, z
y	y coordinates
z	z coordinates. Will supersede x\$z

**Value**

list with components

beta	the coefficients
x	
y	
z	and others for internal use only.

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.  
 Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[trmat](#), [surf.gls](#)

**Examples**

```
library(MASS) # for eqscplot
data(topo, package="MASS")
topo.kr <- surf.ls(2, topo)
trsurf <- trmat(topo.kr, 0, 6.5, 0, 6.5, 50)
eqscplot(trsurf, type = "n")
contour(trsurf, add = TRUE)
points(topo)

eqscplot(trsurf, type = "n")
contour(trsurf, add = TRUE)
plot(topo.kr, add = TRUE)
title(xlab= "Circle radius proportional to Cook's influence statistic")
```

---

trls.influence

*Regression diagnostics for trend surfaces*


---

**Description**

This function provides the basic quantities which are used in forming a variety of diagnostics for checking the quality of regression fits for trend surfaces calculated by `surf.ls`.

**Usage**

```
trls.influence(object)
## S3 method for class 'trls'
plot(x, border = "red", col = NA, pch = 4, cex = 0.6,
      add = FALSE, div = 8, ...)
```

**Arguments**

<code>object, x</code>	Fitted trend surface model from <code>surf.ls</code>
<code>div</code>	scaling factor for influence circle radii in <code>plot.trls</code>
<code>add</code>	add influence plot to existing graphics if TRUE
<code>border, col, pch, cex, ...</code>	additional graphical parameters

**Value**

`trls.influence` returns a list with components:

<code>r</code>	raw residuals as given by <code>residuals.trls</code>
<code>hii</code>	diagonal elements of the Hat matrix
<code>stresid</code>	standardised residuals
<code>Di</code>	Cook's statistic

## References

- Unwin, D. J., Wrigley, N. (1987) Towards a general-theory of control point distribution effects in trend surface models. *Computers and Geosciences*, **13**, 351–355.
- Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

## See Also

[surf.ls](#), [influence.measures](#), [plot.lm](#)

## Examples

```
library(MASS) # for eqscplot
data(topo, package = "MASS")
topo2 <- surf.ls(2, topo)
infl.topo2 <- trls.influence(topo2)
(cand <- as.data.frame(infl.topo2)[abs(infl.topo2$stresid) > 1.5, ])
cand.xy <- topo[as.integer(rownames(cand)), c("x", "y")]
trsurf <- trmat(topo2, 0, 6.5, 0, 6.5, 50)
eqscplot(trsurf, type = "n")
contour(trsurf, add = TRUE, col = "grey")
plot(topo2, add = TRUE, div = 3)
points(cand.xy, pch = 16, col = "orange")
text(cand.xy, labels = rownames(cand.xy), pos = 4, offset = 0.5)
```

---

trmat

*Evaluate Trend Surface over a Grid*

---

## Description

Evaluate trend surface over a grid.

## Usage

```
trmat(obj, xl, xu, yl, yu, n)
```

## Arguments

obj	object returned by <code>surf.ls</code> or <code>surf.gls</code>
xl	limits of the rectangle for grid
xu	
yl	
yu	
n	use $n \times n$ grid within the rectangle

## Value

list with components `x`, `y` and `z` suitable for `contour` and `image`.

**References**

- Ripley, B. D. (1981) *Spatial Statistics*. Wiley.  
Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[surf.ls](#), [surf.gls](#)

**Examples**

```
data(topo, package="MASS")
topo.kr <- surf.ls(2, topo)
trsurf <- trmat(topo.kr, 0, 6.5, 0, 6.5, 50)
```

---

variogram

*Compute Spatial Variogram*

---

**Description**

Compute spatial (semi-)variogram of spatial data or residuals.

**Usage**

```
variogram(krig, nint, plotit = TRUE, ...)
```

**Arguments**

krig	trend-surface or kriging object with columns x, y, and z
nint	number of bins used
plotit	logical for plotting
...	parameters for the plot

**Details**

Divides range of data into `nint` bins, and computes the average squared difference for pairs with separation in each bin. Returns results for bins with 6 or more pairs.

**Value**

x and y coordinates of the variogram and `cnt`, the number of pairs averaged per bin.

**Side Effects**

Plots the variogram if `plotit = TRUE`

**References**

Ripley, B. D. (1981) *Spatial Statistics*. Wiley.

Venables, W. N. and Ripley, B. D. (2002) *Modern Applied Statistics with S*. Fourth edition. Springer.

**See Also**

[correlogram](#)

**Examples**

```
data(topo, package="MASS")
topo.kr <- surf.ls(2, topo)
variogram(topo.kr, 25)
```

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