

Package ‘CompRandFld’

June 24, 2010

Version 0.1

Date 2010-04-06

Title Composite-likelihood based Analysis of Random Fields

Author Simone Padoan <simone.padoan@epfl.ch>, Moreno Bevilacqua
<bevilacqua@stat.unipd.it>

Maintainer Simone Padoan <simone.padoan@epfl.ch>

Depends R (>= 2.9.0)

Description The aim of this package is to collect a set of procedures for the analysis of Random Fields by Composite Likelihood methods. Spatial analysis often involves dealing with large dataset. Therefore even simple studies may be too computationally demanding. Composite likelihood based methods are emerging as useful tools for mitigating such computational problems and show satisfactory results when compared with other techniques such as, for example the tapering method. Moreover, composite likelihood (and related quantities) have some good properties similar to those of the standard likelihood.

Suggests RandomFields, rootSolve

License GPL Version 2 or later

URL <http://eflum.epfl.ch/people/padoan.en.php>

R topics documented:

CheckCorrModel	2
CheckInput	2
CheckLikelihood	4
CheckModel	4
CheckParam	5
CheckParamRange	5
CheckType	6
CompLikelihood	6
CorrelationFct	7
CorrelationParam	8
Covariogram	8
DetectParam	10
FitComposite	11

InitParam	17
Likelihood	18
LogNormDen	19
OptimCompLik	19
OptimLik	21
SetRangeParam	22
WLeastSquare	22
Wls	25
WlsInit	26

Index	27
--------------	-----------

CheckCorrModel	<i>Check of the Correlation Model</i>
----------------	---------------------------------------

Description

Subroutine called by InitParam. The procedure controls if the correlation model inserted has been implemented.

Usage

```
CheckCorrModel (corrmodel)
```

Arguments

corrmodel String; the name of a correlation model, for the description see [CovarianceFct](#).

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

CheckInput	<i>Check of the input</i>
------------	---------------------------

Description

Subroutine called by the fitting procedures. The procedure controls the input passed to the fitting procedures.

Usage

```
CheckInput (coordx, coordy, corrmodel, data, fixed,
            grid, likelihood, lonlat, model, optimizer,
            start, varest, time, type, weighted,
            weights)
```

Arguments

<code>coordx</code>	A numeric ($d \times 2$)-matrix (where d is the number of points) assigning 2-dimensions of coordinates or a numeric vector assigning 1-dimension of coordinates.
<code>coordy</code>	A numeric vector assigning 1-dimension of coordinates; <code>coordy</code> is interpreted only if <code>coordx</code> is a numeric vector otherwise it will be ignored.
<code>corrmodel</code>	String; the name of a correlation model, for the description see CovarianceFct .
<code>data</code>	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations.
<code>fixed</code>	A named list giving the values of the parameters that will be considered as known values. The listed parameters for a given correlation function will be not estimated, i.e. if <code>list(nugget=0)</code> the nugget effect is ignored.
<code>grid</code>	Logical; if <code>FALSE</code> (the default) the data are interpreted as a vector or a $(n \times d)$ -matrix, instead if <code>TRUE</code> then $(d \times d \times n)$ -matrix is considered.
<code>likelihood</code>	String; the configuration of the composite likelihood. <code>Marginal</code> is the default.
<code>lonlat</code>	Logical; if <code>FALSE</code> (the default), <code>coordx</code> and <code>coordy</code> are interpreted as Cartesian coordinates otherwise they are considered as longitude and latitude.
<code>model</code>	String; the density associated to the likelihood objects. <code>Gaussian</code> is the default.
<code>optimizer</code>	String; the optimization algorithm (see optim for details). 'Nelder-Mead' is the default.
<code>start</code>	A named list with the initial values of the parameters that are used by the numerical routines in maximization procedure. <code>NULL</code> is the default.
<code>varest</code>	Logical; if <code>TRUE</code> the estimate' variances and standard errors are returned. <code>FALSE</code> is the default.
<code>time</code>	Logical; if <code>FALSE</code> (the default) a spatial random field is considered (one temporal realisation), if <code>TRUE</code> a spatial-temporal random field is considered.
<code>type</code>	String; the type of the likelihood objects. If <code>Pairwise</code> (the default) then the marginal composite likelihood is formed by pairwise marginal likelihoods.
<code>weighted</code>	Logical; if <code>TRUE</code> the likelihood objects are weighted. If <code>FALSE</code> (the default) the composite likelihood is not weighted.
<code>weights</code>	A numeric vector of weights.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

CheckLikelihood	<i>Check of the type of Composite-likelihood</i>
-----------------	--

Description

Subroutine called by InitParam. The procedure controls the type of the composite-likelihood passed to the FitComposite procedure.

Usage

```
CheckLikelihood(likelihood)
```

Arguments

likelihood String; the configuration of the composite likelihood. Marginal is the default.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

CheckModel	<i>Check of the type of Random Field</i>
------------	--

Description

Subroutine called by InitParam. The procedure controls the type of random field passed to the fitting procedures.

Usage

```
CheckModel(model)
```

Arguments

model String; the density associated to the likelihood objects. Gaussian is the default.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

`CheckParam`*Check of the Parameters*

Description

Subroutine called by `InitParam`. The procedure controls the validity of the correlation's parameters.

Usage

```
CheckParam (corrmodel, namesparam, numparam)
```

Arguments

<code>corrmodel</code>	String; the name of a correlation model.
<code>namesparam</code>	String; the names of the parameters.
<code>numparam</code>	Numeric; the number of the parameters.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

`CheckParamRange`*Check of the Parameters' Ranges*

Description

Subroutine called by the fitting procedures. The procedure controls the range of the correlation's parameters.

Usage

```
CheckParamRange (param)
```

Arguments

<code>param</code>	Numeric; a vector of correlation's parameters.
--------------------	--

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

CheckType	<i>Check of the type of likelihood objects</i>
-----------	--

Description

Subroutine called by InitParam. The procedure controls the type of likelihood objects that form the composite-likelihood .

Usage

```
CheckType (type)
```

Arguments

type	String; the type of the likelihood objects. If Pairwise (the default) then the marginal composite likelihood is formed by pairwise marginal likelihoods.
------	--

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

CompLikelihood	<i>Computation of the Composite-likelihood</i>
----------------	--

Description

Subroutine called by OptimCompLik. The procedure computes the composite-likelihood for a given set of data and parameters.

Usage

```
CompLikelihood(coordx, coordy, corrmodel, data, dista, fixed, lags,
               model, namescorr, namesnuis, numcoord, numdata, param,
               type)
```

Arguments

coordx	A numeric ($d \times 2$)-matrix (where d is the number of points) assigning 2-dimensions of coordinates or a numeric vector assigning 1-dimension of coordinates.
coordy	A numeric vector assigning 1-dimension of coordinates; coordy is interpreted only if coordx is a numeric vector otherwise it will be ignored.
corrmodel	Numeric; the id of the correlation model.
data	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations.
dista	A numeric value specifying the cut-off distance.

<code>fixed</code>	A numeric vector with the parameters that will be considered as known values.
<code>lags</code>	A numeric vector of distances between points.
<code>model</code>	Numeric; the id of the random field.
<code>namescorr</code>	String; the names of the correlation parameters.
<code>namesnuis</code>	String; the names of the nuisance parameters.
<code>numcoord</code>	Numeric; the number of coordinates.
<code>numdata</code>	Numeric; the number of the data in time.
<code>param</code>	A numeric vector with the parameter values.
<code>type</code>	String; the type of the likelihood objects. If <code>Pairwise</code> (the default) then the marginal composite likelihood is formed by pairwise marginal likelihoods.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

CorrelationFct

Computation of the Correlation function

Description

Subroutine called by `Covariogram`. The procedure computes the estimated correlation function for a given fitted model.

Usage

```
CorrelationFct(corrmodel, lags, numpairs, param)
```

Arguments

<code>corrmodel</code>	Numeric; the id of the correlation model.
<code>lags</code>	A numeric vector of distances between points.
<code>numpairs</code>	Numeric; the number of distances.
<code>param</code>	A numeric vector with the parameter values.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

CorrelationParam	<i>Lists the Parameters of the Correlation function</i>
------------------	---

Description

Subroutine called by DetectParam and InitParam. The procedure returns the list of the parameter for a given correlation model.

Usage

```
CorrelationParam(corrmodel)
```

Arguments

corrmodel	String; the name of a correlation model.
-----------	--

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

Covariogram	<i>Computation of the covariance function and the variogram</i>
-------------	---

Description

The procedure computes and plots the estimated covariance function and the variogram from a fitted model obtained fitting a random field with the composite-likelihood or using the weighted least square method.

Usage

```
Covariogram(fitted, lags=NULL, answer.cov=FALSE, answer.vario=FALSE,
            answer.range=FALSE, show.cov=FALSE, show.vario=FALSE,
            show.range=FALSE, add.cov=FALSE, add.vario=FALSE,
            pract.range=95, ...)
```

Arguments

fitted	The fitted object obtained from the FitComposite procedure.
lags	A numeric vector of distances.
answer.cov	Logical; if TRUE a vector with the estimated covariance function is returned; if FALSE (the default) the covariance is not returned.
answer.vario	Logical; if TRUE a vector with the estimated variogram is returned; if FALSE (the default) the variogram is not returned.

<code>answer.range</code>	Logical; if TRUE the estimated practical range is returned; if FALSE (the default) the practical range is not returned.
<code>show.cov</code>	Logical; if TRUE the estimated covariance function is plotted; if FALSE (the default) the covariance function is not plotted.
<code>show.vario</code>	Logical; if TRUE the estimated variogram is plotted; if FALSE (the default) the variogram is not plotted.
<code>show.range</code>	Logical; if TRUE the estimated practical range is added on the plot; if FALSE (the default) the practical range is not added.
<code>add.cov</code>	Logical; if TRUE the vector of the estimated covariance function is added on the current plot; if FALSE (the default) the covariance is not added.
<code>add.vario</code>	Logical; if TRUE the vector with the estimated variogram is added on the current plot; if FALSE (the default) the correlation is not added.
<code>pract.range</code>	Numeric; the percent of the sill to be reached.
<code>...</code>	other optional parameters which are passed to plot function.

Value

The returned object is a list with:

- `covariance`, the vector of the estimated covariance function;
- `variogram`, the vector of the estimated variogram function;
- `practical.range`, the estimated practical range;

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

Examples

```
library(RandomFields)
set.seed(2111)

# Set the coordinates of the points:
x <- runif(100, 0, 20)
y <- runif(100, 0, 20)

#####
###
### Example 1. Plot of the estimated correlation function
### from a spatial realisation of a Gaussian random field.
###
###
#####

# Set the model's parameters:
corrmodel <- "stable"
mean <- 0
variance <- 3
nugget <- 1
scale <- 10
power <- 1.5
```

```
# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=FALSE,
               param=c(mean, variance, nugget, scale, power))

# Maximum composite-likelihood fitting of the random field:
fit <- FitComposite(x, y, corrmodel, sim)

# Plot of the Correlation function:
par(mfrow=c(1,2))
Covariogram(fit, show.cov=TRUE, show.range=TRUE, show.vario=TRUE)
```

DetectParam

Identification of the Parameters of the Correlation function

Description

Subroutine called by Covariogram and others The procedure returns a list with the correlation model and the list of parameters.

Usage

```
DetectParam(corrmodel, fixed, param)
```

Arguments

corrmodel	String; the name of a correlation model.
fixed	A numeric vector with the fixed parameters.
param	A numeric vector with the parameters.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

Description

Maximum composite-likelihood fitting for random fields. The function returns the parameters' estimates and the estimates' variances of random fields obtained by maximisation of the composite-likelihood and allows to fix any of the parameters.

Usage

```
FitComposite(coordx, coordy=NULL, corrmmodel, data, fixed=NULL,
             grid=FALSE, hessian=FALSE, likelihood='Marginal',
             lonlat=FALSE, model='Gaussian', optimizer='Nelder-Mead',
             start=NULL, varest=FALSE, time=FALSE, type='Pairwise',
             weighted=FALSE, weights=NULL)
```

Arguments

<code>coordx</code>	A numeric ($d \times 2$)-matrix (where d is the number of points) assigning 2-dimensions of coordinates or a numeric vector assigning 1-dimension of coordinates.
<code>coordy</code>	A numeric vector assigning 1-dimension of coordinates; <code>coordy</code> is interpreted only if <code>coordx</code> is a numeric vector otherwise it will be ignored.
<code>corrmmodel</code>	String; the name of a correlation model, for the description see the Section Details .
<code>data</code>	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations (see Details).
<code>fixed</code>	A named list giving the values of the parameters that will be considered as known values. The listed parameters for a given correlation function will be not estimated, i.e. if <code>list(nugget=0)</code> the nugget effect is ignored.
<code>grid</code>	Logical; if <code>FALSE</code> (the default) the data are interpreted as a vector or a $(n \times d)$ -matrix, instead if <code>TRUE</code> then $(d \times d \times n)$ -matrix is considered.
<code>hessian</code>	Logical; if <code>FALSE</code> (the default) the hessian matrix is not computed from the optimizer routine.
<code>likelihood</code>	String; the configuration of the composite likelihood. <code>Marginal</code> is the default, see the Section Details .
<code>lonlat</code>	Logical; if <code>FALSE</code> (the default), <code>coordx</code> and <code>coordy</code> are interpreted as Cartesian coordinates otherwise they are considered as longitude and latitude.
<code>model</code>	String; the density associated to the likelihood objects. <code>Gaussian</code> is the default, see the Section Details .
<code>optimizer</code>	String; the optimization algorithm (see optim for details). 'Nelder-Mead' is the default.
<code>start</code>	A named list with the initial values of the parameters that are used by the numerical routines in maximization procedure. <code>NULL</code> is the default (see Details).
<code>varest</code>	Logical; if <code>TRUE</code> the estimate' variances and standard errors are returned. <code>FALSE</code> is the default.

<code>time</code>	Logical; if <code>FALSE</code> (the default) a spatial random field is considered (one temporal realisation), if <code>TRUE</code> a spatial-temporal random field is considered, see the Section Details .
<code>type</code>	String; the type of the likelihood objects. If <code>Pairwise</code> (the default) then the marginal composite likelihood is formed by pairwise marginal likelihoods (see Details).
<code>weighted</code>	Logical; if <code>TRUE</code> the likelihood objects are weighted, see the Section Details . If <code>FALSE</code> (the default) the composite likelihood is not weighted.
<code>weights</code>	A numeric vector of weights (see Details).

Details

The `corrmodel` parameter allows to select a specific correlation function for the random field. The implemented correlation models are:

1. `cauchy`;
2. `exponential`;
3. `gauss` (Gaussian);
4. `gencauchy` (generalised Cauchy);
5. `stable` (or powered exponential);
6. `whittlematern` (Whittle-Matern).

See for more details [CovarianceFct](#).

With the `data` parameter:

- If a numeric vector, the data are interpreted as one spatial realisation;
- If a numeric $(n \times d)$ -matrix, the columns represent the data observed at different points and the rows represent the data for different time steps.
- If a numeric $(d \times d \times n)$ -matrix the data are observed at $(d \times d)$ points for n time steps.

The `likelihood` parameter represents the composite-likelihood configurations. The settings alternatives are:

1. `Conditional`, the composite-likelihood is formed by conditionals likelihoods (not implemented yet);
2. `Marginal`, the composite-likelihood is formed by marginals likelihoods;
3. `Full`, the composite-likelihood turns out to be the standard likelihood;

The `model` parameter represents the density function underlying the definition of the likelihoods which form the composite-likelihood. The settings alternatives are:

- `Gaussian`, the Gaussian density.

The `start` parameter allows to specify starting values. If `start` is omitted the routine is computing the starting values using the weighted moment estimator.

The `time` parameter allows to specify the type of random field. If `FALSE` a spatial random field is considered, if `TRUE` a spatial-temporal random field is used. For the moment the case of i.i.d. time replications is implemented. Soon will be possible to specify also dependence structure for the temporal component.

The `type` parameter represents the type of likelihood used in the composite-likelihood definition. The settings alternatives are:

1. If the composite is formed by Marginal likelihoods:
 - If each likelihood is obtained by the Gaussian density then with:
 - Pairwise, the composite-likelihood is defined by the pairwise likelihoods;
 - Difference, the composite-likelihood is defined by likelihoods which are obtained as difference of the pairwise likelihoods.
2. If the Full likelihood is considered:
 - If the likelihood is obtained by the Gaussian density then with:
 - Standard, the likelihood used is the standard version;
 - Restricted, the likelihood used is the restricted version.

The `weighted` parameter specifies if the likelihoods forming the composite-likelihood must be weighted. If `TRUE` the weights are selected by opportune procedures that improve the efficient of the maximum composite-likelihood estimator (not implemented yet). If `FALSE` the efficient improvement procedure is not used.

The `weights` parameter allows to weight the composite-likelihood by weights insert by the users. These do not imply any gain in efficiency of the maximum composite-likelihood estimator but still be a reasonable setting.

Value

The returned object is a list with:

- `clic`, the composite information criterion, if the full likelihood is considered then it coincide with the Akaike information criterion;
- `coord`, the vector of coordinates;
- `convergence`, a string that denotes if convergence is reached;
- `corrmodel`, the correlation model;
- `data`, the vector or matrix of data;
- `fixed`, the vector of fixed parameters;
- `iterations`, the number of iteration used by the numerical routine;
- `likelihood`, the configuration of the composite likelihood;
- `logCompLik`, the value of the log composite-likelihood at the maximum;
- `lonlat`, the type of coordinates;
- `message`, extra message passed from the numerical routines;
- `model`, the density associated to the likelihood objects;
- `param`, the vector of parameters' estimates;
- `stderr`, the vector of standard errors;
- `sensmat`, the sensitivity matrix;
- `varcov`, the matrix of the variance-covariance of the estimates;
- `varimat`, the variability matrix;
- `type`, the type of the likelihood objects.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>; Moreno Bevilacqua, <moreno.bevilacqua@unive.it>.

References

- Harville, D. A. (1977) Maximum Likelihood Approaches to Variance Component Estimation and to Related Problems. *Journal of the American Statistical Association*, **72**, 320–338.
- Varin, C. and Vidoni, P. (2005) A Note on Composite Likelihood Inference and Model Selection. *Biometrika*, **92**, 519–528.
- Varin, C. (2008) On Composite Marginal Likelihoods. *Advances in Statistical Analysis*, **92**, 1–28.
- Padoan, S. A. Ribatet, M and Sisson, S. A. (2010) Likelihood-Based Inference for Max-Stable Processes. *Journal of the American Statistical Association, Theory & Methods*, **105**, 263–277.

See Also

[CovarianceFct](#), [WLeastSquare](#), [optim](#)

Examples

```
library(RandomFields)
set.seed(2111)

# Set the coordinates of the points:
x <- runif(100, 0, 20)
y <- runif(100, 0, 20)

#####
###
### Example 1. Maximum composite-likelihood fitting of one
### spatial realisation of a Gaussian random field.
### Composite-likelihood setting: pairwise marginal likelihoods.
###
#####

# Set the model's parameters:
corrmodel <- "stable"
mean <- 0
variance <- 1
nugget <- 0
scale <- 10
power <- 1.5

# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=FALSE,
               param=c(mean, variance, nugget, scale, power))

# Maximum composite-likelihood fitting of the random field:
fit <- FitComposite(x, y, corrmodel, sim)

# Results:
print(fit)

#####
###
### Example 2. Maximum composite-likelihood fitting of one
### spatial realisation of a Gaussian random field.
### Composite-likelihood setting: difference likelihoods.
```

```

###
#####

# Set the model's parameters:
corrmodel <- "stable"
mean <- 0
variance <- 1
nugget <- 0
scale <- 10
power <- 1.5

# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=FALSE,
               param=c(mean, variance, nugget, scale, power))

# Maximum composite-likelihood fitting of the random field:
fit <- FitComposite(x, y, corrmodel, sim, type='Difference')

# Results:
print(fit)

#####
###
### Example 3. Maximum likelihood fitting of one
### spatial realisation of a Gaussian random field.
### Likelihood setting: restricted likelihood.
###
#####

# Set the model's parameters:
corrmodel <- "stable"
mean <- 0
variance <- 1
nugget <- 0
scale <- 10
power <- 1.5

# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=FALSE,
               param=c(mean, variance, nugget, scale, power))

# Maximum composite-likelihood fitting of the random field:
fit <- FitComposite(x, y, corrmodel, sim, likelihood='Full',
                   type='Restricted')

# Results:
print(fit)

#####
###
### Example 4. Maximum composite-likelihood fitting of n i.i.d.
### spatial realisations of a Gaussian random field.
### Composite-likelihood setting: difference likelihoods.
###

```

```
#####

numdata <- 30

# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=FALSE, n = numdata,
               param=c(mean, variance, nugget, scale, power), pch='')

sim <- t(sim)

# Maximum composite-likelihood fitting of the random field:
fit <- FitComposite(x, y, corrmodel, sim, time=TRUE, type='Difference')

# Results:
print(fit)

#####
###
### Example 5. Maximum composite-likelihood fitting of one
### spatial realisations of a Gaussian random field on a
### regular grid.
### Composite-likelihood setting: difference likelihoods.
###
#####

step <- 1
x <- seq(0, 20, step)
y <- seq(0, 20, step)

# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=TRUE,
               param=c(mean, variance, nugget, scale, power))

# Maximum composite-likelihood fitting of the random field:
fit <- FitComposite(x, y, corrmodel, sim, grid=TRUE, type='Difference')

# Results:
print(fit)

#####
###
### Example 6. Maximum composite-likelihood fitting of n i.i.d.
### spatial realisations of a Gaussian random field on a
### regular grid.
### Composite-likelihood setting: difference likelihoods.
###
#####

numdata <- 5

# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=TRUE, n = numdata,
               param=c(mean, variance, nugget, scale, power), pch='')

```



```
# Maximum composite-likelihood fitting of the random field:
fit <- FitComposite(x, y, corrmmodel, sim, grid=TRUE, time=TRUE,
                  type='Difference')

# Results:
print(fit)
```

InitParam

*Initialization of the Fitting Procedures***Description**

Subroutine called by the fitting procedures. The procedure initializes the fitting procedure.

Usage

```
InitParam(coordx, coordy, corrmmodel, data, fixed, grid,
          likelihood, lonlat, model, parscale, paramrange,
          start, time, type)
```

Arguments

<code>coordx</code>	A numeric ($d \times 2$)-matrix (where d is the number of points) assigning 2-dimensions of coordinates or a numeric vector assigning 1-dimension of coordinates.
<code>coordy</code>	A numeric vector assigning 1-dimension of coordinates; <code>coordy</code> is interpreted only if <code>coordx</code> is a numeric vector otherwise it will be ignored.
<code>corrmmodel</code>	String; the name of a correlation model.
<code>data</code>	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations.
<code>fixed</code>	A named list giving the values of the parameters that will be considered as known values.
<code>grid</code>	Logical; if <code>FALSE</code> (the default) the data are interpreted as a vector or a $(n \times d)$ -matrix, instead if <code>TRUE</code> then $(d \times d \times n)$ -matrix is considered.
<code>likelihood</code>	String; the configuration of the composite likelihood.
<code>lonlat</code>	Logical; if <code>FALSE</code> (the default), <code>coordx</code> and <code>coordy</code> are interpreted as Cartesian coordinates otherwise they are considered as longitude and latitude.
<code>model</code>	String; the density associated to the likelihood objects. <code>Gaussian</code> is the default.
<code>parscale</code>	A numeric vector of scaling factor to improve the maximizing procedure, see optim .
<code>paramrange</code>	A numeric vector of parameters ranges, see optim .
<code>start</code>	A named list with the initial values of the parameters that are used by the numerical routines in maximization procedure. <code>NULL</code> is the default (see Details).
<code>time</code>	Logical; if <code>FALSE</code> (the default) a spatial random field is considered (one temporal realisation), if <code>TRUE</code> a spatial-temporal random field is considered.
<code>type</code>	String; the type of the likelihood objects. If <code>Pairwise</code> (the default) then the marginal composite likelihood is formed by pairwise marginal likelihoods.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

Likelihood	<i>Computation of the likelihood</i>
------------	--------------------------------------

Description

Subroutine called by OptimLik. The procedure computes the likelihood function for a given set of data and parameters.

Usage

```
Likelihood(corrmodel, data, fixed, grid, lags, model,
           namescorr, namesnuis, numcoord, numdata,
           numpairs, param, type)
```

Arguments

corrmodel	String; the name of a correlation model.
data	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations.
fixed	A named list giving the values of the parameters that will be considered as known values.
grid	Logical; if FALSE (the default) the data are interpreted as a vector or a $(n \times d)$ -matrix, instead if TRUE then $(d \times d \times n)$ -matrix is considered.
lags	A numeric vector of distances between points.
model	String; the density associated to the likelihood objects. Gaussian is the default.
namescorr	String; the names of the correlation parameters.
namesnuis	String; the names of the nuisance parameters.
numcoord	Numeric; the number of coordinates;
numdata	Numeric; the number of data replications in time.
numpairs	Numeric; the number of pairwise points.
param	A numeric vector of parameters' values.
type	String; the type of the likelihood objects. If Pairwise (the default) then the marginal composite likelihood is formed by pairwise marginal likelihoods.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

LogNormDen

Computation of the multivariate log-normal density

Description

Subroutine called by the Likelihood procedure. The procedure compute the multivariate log-normal density for a given set of data and parameters.

Usage

```
LogNormDen(stdata, detvarcov, ivarcov, numcoord, type)
```

Arguments

stdata	A numeric vector ($d \times 1$) of data.
detvarcov	Numeric; the determinant of the variance-covariance matrix.
ivarcov	The inverse of the variance-covariance matrix ($d \times d$).
numcoord	The number of point's coordinates.
type	The numeric id denoting the type of likelihood.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

OptimCompLik

Optimization of the Composite log-likelihood

Description

Subroutine called by FitComposite. The procedure estimates the model parameters by maximisation of the composite log-likelihood.

Usage

```
OptimCompLik(coordx, coordy, corrmodel, data, flagcorr,
             flagnuis, fixed, grid, hessian, lags, lower,
             model, namescorr, namesnuis, namesparam,
             numcoord, numdata, numparam, numparamcorr,
             optimizer, param, varest, type, upper, weighted)
```

Arguments

<code>coordx</code>	A numeric ($d \times 2$)-matrix (where d is the number of points) assigning 2-dimensions of coordinates or a numeric vector assigning 1-dimension of coordinates.
<code>coordy</code>	A numeric vector assigning 1-dimension of coordinates; <code>coordy</code> is interpreted only if <code>coordx</code> is a numeric vector otherwise it will be ignored.
<code>corrmodel</code>	Numeric; the id of the correlation model.
<code>data</code>	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations.
<code>flagcorr</code>	A numeric vector of binary values denoting which parameters of the correlation function will be estimated.
<code>flagnuis</code>	A numeric vector of binary values denoting which nuisance parameters will be estimated.
<code>fixed</code>	A numeric vector of parameters that will be considered as known values.
<code>grid</code>	Logical; if <code>FALSE</code> (the default) the data are interpreted as a vector or a $(n \times d)$ -matrix, instead if <code>TRUE</code> then $(d \times d \times n)$ -matrix is considered.
<code>hessian</code>	Logical; if <code>FALSE</code> (the default) the hessian matrix is not computed from the optimizer routine.
<code>lags</code>	A numeric vector of distances between points.
<code>lower</code>	A numeric vector with the lower bounds of the parameters' ranges.
<code>model</code>	Numeric; the id value of the density associated to the likelihood objects.
<code>namescorr</code>	String; the names of the correlation parameters.
<code>namesnuis</code>	String; the names of the nuisance parameters.
<code>namesparam</code>	String; the names of the parameters to be maximised.
<code>numcoord</code>	Numeric; the number of coordinates.
<code>numdata</code>	Numeric; the number of data replications in time.
<code>numparam</code>	Numeric; the number of parameters to be maximised.
<code>numparamcorr</code>	Numeric; the number of correlation parameters.
<code>optimizer</code>	String; the optimization algorithm (see <code>optim</code> for details). 'Nelder-Mead' is the default.
<code>param</code>	A numeric vector of parameters' values.
<code>varest</code>	Logical; if <code>TRUE</code> the estimate' variances and standard errors are returned. <code>FALSE</code> is the default.
<code>type</code>	String; the type of the likelihood objects. If <code>Pairwise</code> (the default) then the marginal composite likelihood is formed by pairwise marginal likelihoods.
<code>upper</code>	A numeric vector with the upper bounds of the parameters' ranges.
<code>weighted</code>	Logical; if <code>TRUE</code> the likelihood objects are weighted, see the Section Details . If <code>FALSE</code> (the default) the composite likelihood is not weighted.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

Description

Subroutine called by FitComposite. The procedure estimates the model parameters by maximisation of the log-likelihood.

Usage

```
OptimLik(corrmodel, data, fixed, grid, hessian, lags, lower,
        model, namescorr, namesnuis, namesparam, numcoord,
        numdata, numpairs, optimizer, param, varest, type,
        upper)
```

Arguments

corrmodel	Numeric; the id of the correlation model.
data	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations.
fixed	A numeric vector of parameters that will be considered as known values.
grid	Logical; if FALSE (the default) the data are interpreted as a vector or a $(n \times d)$ -matrix, instead if TRUE then $(d \times d \times n)$ -matrix is considered.
hessian	Logical; if FALSE (the default) the hessian matrix is not computed from the optimizer routine.
lags	A numeric vector of distances between points.
lower	A numeric vector with the lower bounds of the parameters' ranges.
model	Numeric; the id value of the density associated to the likelihood objects.
namescorr	String; the names of the correlation parameters.
namesnuis	String; the names of the nuisance parameters.
namesparam	String; the names of the parameters to be maximised.
numcoord	Numeric; the number of coordinates.
numdata	Numeric; the number of data replications in time.
numpairs	Numeric; the number of pairwise distances.
optimizer	String; the optimization algorithm (see optim for details). 'Nelder-Mead' is the default.
param	A numeric vector of parameters' values.
varest	Logical; if TRUE the estimate' variances and standard errors are returned. FALSE is the default.
type	String; the type of the likelihood objects. If Pairwise (the default) then the marginal composite likelihood is formed by pairwise marginal likelihoods.
upper	A numeric vector with the upper bounds of the parameters' ranges.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

SetRangeParam	<i>Identification of the Parameters' Range</i>
---------------	--

Description

Subroutine called by InitParam and the fitting procedures. The procedure returns the range of the parameters for a given vector of parameters.

Usage

```
SetRangeParam(namesparam, numparam)
```

Arguments

namesparam	String; the names of the parameters.
numparam	Numeric; the number of parameters.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#)

WLeastSquare	<i>Weighted Least Square Estimation of Random Fields</i>
--------------	--

Description

the function returns the parameters' estimates and the estimates' variances of a random field obtained by the weighed least squares estimator.

Usage

```
WLeastSquare(coordx, coordy, corrmodel, data, fixed=NULL,
              grid=FALSE, lonlat=FALSE, maxdist=NULL,
              optimizer='Nelder-Mead', numbins=NULL, start=NULL,
              time=FALSE, weighted=FALSE)
```

Arguments

<code>coordx</code>	A numeric ($d \times 2$)-matrix (where d is the number of points) assigning 2-dimensions of coordinates or a numeric vector assigning 1-dimension of coordinates.
<code>coordy</code>	A numeric vector assigning 1-dimension of coordinates; <code>coordy</code> is interpreted only if <code>coordx</code> is a numeric vector otherwise it will be ignored.
<code>corrmodel</code>	String; the name of a correlation model, for the description (see FitComposite).
<code>data</code>	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations (see FitComposite).
<code>fixed</code>	A named list giving the values of the parameters that will be considered as known values. The listed parameters for a given correlation function will be not estimated, i.e. if <code>list(nugget=0)</code> the nugget effect is ignored.
<code>grid</code>	Logical; if <code>FALSE</code> (the default) the data are interpreted as a vector or a $(n \times d)$ -matrix, instead if <code>TRUE</code> then $(d \times d \times n)$ -matrix is considered.
<code>lonlat</code>	Logical; if <code>FALSE</code> (the default), <code>coordx</code> and <code>coordy</code> are interpreted as Cartesian coordinates otherwise they are considered as longitude and latitude.
<code>maxdist</code>	A numeric value denoting the maximum distance, see the Section Details .
<code>optimizer</code>	String; the optimization algorithm (see optim for details). 'Nelder-Mead' is the default.
<code>numbins</code>	A numeric value denoting the numbers of bins, see the Section Details
<code>start</code>	A named list with the initial values of the parameters that are used by the numerical routines in maximization procedure. <code>NULL</code> is the default (see FitComposite).
<code>time</code>	Logical; if <code>FALSE</code> (the default) a spatial random field is considered (one temporal realisation), if <code>TRUE</code> a spatial-temporal random field is considered (see FitComposite).
<code>weighted</code>	Logical; if <code>TRUE</code> then the weighted least square estimator is considered. If <code>FALSE</code> (the default) then the classic least square is used.

Details

Insert description of `maxdist` and `numbins`.

Value

The returned object is a list with:

- `bins`, adjacent intervals of grouped distances;
- `coord`, the vector of coordinates;
- `convergence`, a string that denotes if convergence is reached;
- `corrmodel`, the correlation model;
- `data`, the vector or matrix of data;
- `fixed`, the vector of fixed parameters;
- `iterations`, the number of iteration used by the numerical routine;
- `message`, extra message passed from the numerical routines;
- `param`, the vector of parameters' estimates;
- `variogram` the empirical variogram;

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>; Moreno Bevilacqua, <moreno.bevilacqua@unive.it>.

References

Cressie, N. A. C. (1993) Statistics for Spatial Data. New York: Wiley.
 Barry, J. T., Crowder, M. J. and Diggle, P. J. (1997) Parametric estimation of the variogram. Tech. Report, Dept Maths & Stats, Lancaster University.

See Also

[FitComposite](#), [optim](#)

Examples

```
library(RandomFields)
set.seed(2111)

# Set the coordinates of the sites:
x <- runif(100, 0, 20)
y <- runif(100, 0, 20)

#####
###
### Example 1. Least square fitting of one
### spatial realisation of a Gaussian random field.
### Non weighted version (all weights equals to 1)
###
#####

# Set the model's parameters:
corrmodel <- "stable"
mean <- 0
variance <- 1
nugget <- 0
scale <- 10
power <- 1.5

# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=FALSE,
               param=c(mean, variance, nugget, scale, power))

# Least square fitting of the random field:
fit <- WLeastSquare(x, y, corrmodel, sim)

# Results:
print(fit)

#####
###
### Example 1. Weighted least square fitting of one
### spatial realisation of a Gaussian random field.
### Weighted version.
```



```
###
#####

# Set the model's parameters:
corrmodel <- "stable"
mean <- 0
variance <- 1
nugget <- 0
scale <- 10
power <- 1.5

# Simulation of the Gaussian random field in the specified points:
sim <- GaussRF(x=x, y=y, model=corrmodel, grid=FALSE,
               param=c(mean, variance, nugget, scale, power))

# Least square fitting of the random field:
fit <- WLeastSquare(x, y, corrmodel, sim, weighted=TRUE)

# Results:
print(fit)
```

Wls

Computation of the Weighted Least Squares

Description

Subroutine called by WLeastSquare. The procedure computes the weighted least squares for a given set of data and parameters.

Usage

```
Wls(bins, corrmodel, fixed, lenbins, moments, numbins, param, weighted)
```

Arguments

<code>bins</code>	A numeric vector with adjacent intervals of grouped distances
<code>corrmodel</code>	Numeric; the id of the correlation mode.
<code>fixed</code>	A named list giving the values of the parameters that will be considered as known values.
<code>lenbins</code>	A numeric vector with the number of observations that fall in each bin.
<code>moments</code>	
<code>numbins</code>	Numeric; the number of bins.
<code>param</code>	A numeric vector of parameters' values.
<code>weighted</code>	Logical; if TRUE the least squares are weighted.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[WLeastSquare](#), [FitComposite](#)

WlsInit

Computation of Starting Values based on Weighted Least Squares

Description

Subroutine called by FitComposite. The function returns opportune starting values for the composite-likelihood fitting procedure based on weighed least squares.

Usage

```
WlsInit(coordx, coordy, corrmodel, data, fixed, grid,
        likelihood, lonlat, model, parscale, paramrange,
        start, time, type)
```

Arguments

coordx	A numeric ($d \times 2$)-matrix (where d is the number of points) assigning 2-dimensions of coordinates or a numeric vector assigning 1-dimension of coordinates.
coordy	A numeric vector assigning 1-dimension of coordinates; <code>coordy</code> is interpreted only if <code>coordx</code> is a numeric vector otherwise it will be ignored.
corrmodel	String; the name of a correlation model, for the description.
data	A numeric vector or a $(n \times d)$ -matrix or $(d \times d \times n)$ -matrix of observations.
fixed	A named list giving the values of the parameters that will be considered as known values.
grid	Logical; if FALSE (the default) the data are interpreted as a vector or a $(n \times d)$ -matrix, instead if TRUE then $(d \times d \times n)$ -matrix is considered.
likelihood	String; the configuration of the composite likelihood.
lonlat	Logical; if FALSE (the default), <code>coordx</code> and <code>coordy</code> are interpreted as Cartesian coordinates otherwise they are considered as longitude and latitude.
model	String; the name of the model. Here the default is NULL.
parscale	A numeric vector with scaling values for improving the maximisation routine.
paramrange	A numeric vector with the range of the parameter space.
start	A numeric vector with starting values.
time	Logical; if FALSE (the default) a spatial random field is considered (one temporal realisation), if TRUE a spatial-temporal random field is considered.
type	String; the type of estimation method.

Author(s)

Simone Padoan, <simone.padoan@epfl.ch>, <http://eflum.epfl.ch/people/padoan.en.php>.

See Also

[FitComposite](#), [WLeastSquare](#).

Index

*Topic **Composite**

- CheckCorrModel, 1
- CheckInput, 2
- CheckLikelihood, 3
- CheckModel, 4
- CheckParam, 4
- CheckParamRange, 5
- CheckType, 5
- CompLikelihood, 6
- CorrelationFct, 7
- CorrelationParam, 7
- Covariogram, 8
- DetectParam, 9
- FitComposite, 10
- InitParam, 16
- Likelihood, 17
- LogNormDen, 18
- OptimCompLik, 19
- OptimLik, 20
- SetRangeParam, 21
- Wls, 24

*Topic **LeastSquare**

- WLeastSquare, 22
- WlsInit, 25

- CheckCorrModel, 1
- CheckInput, 2
- CheckLikelihood, 3
- CheckModel, 4
- CheckParam, 4
- CheckParamRange, 5
- CheckType, 5
- CompLikelihood, 6
- CorrelationFct, 7
- CorrelationParam, 7
- CovarianceFct, 2, 11, 13
- Covariogram, 8

- DetectParam, 9

- FitComposite, 2–8, 10, 10, 17, 18, 20–23, 25, 26

- InitParam, 16

- Likelihood, 17

- LogNormDen, 18

- optim, 2, 11, 13, 17, 19, 21–23

- OptimCompLik, 19

- OptimLik, 20

- print.FitComposite

- (FitComposite), 10

- print.WLS (WLeastSquare), 22

- SetRangeParam, 21

- WLeastSquare, 13, 22, 25, 26

- Wls, 24

- WlsInit, 25