Package ‘spacetime’

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Version 1.3-1

Title Classes and Methods for Spatio-Temporal Data

Depends R (>= 3.0.0)

Imports graphics, utils, stats, methods, lattice, sp (>= 1.1-0), zoo
   (>= 1.7-9), xts (>= 0.8-8), intervals

Suggests adehabitatLT, cshapes (>= 2.0), foreign, gstat (>= 1.0-16),
   maps, mapdata, plm, raster, RColorBrewer, rmarkdown,
   RPostgreSQL, knitr, googleVis, ISOcodes, markdown, sf, sftime

LazyData no

Description Classes and methods for spatio-temporal data, including space-time regular lattices, sparse lattices, irregular data, and trajectories; utility functions for plotting data as map sequences (lattice or animation) or multiple time series; methods for spatial and temporal selection and subsetting, as well as for spatial/temporal/spatio-temporal matching or aggregation, retrieving coordinates, print, summary, etc.

License GPL (>= 2)

URL https://github.com/edzer/spacetime

BugReports https://github.com/edzer/spacetime/issues

Encoding UTF-8

VignetteBuilder knitr

Collate Class-xts.R Class-ST.R Class-STFDF.R Class-STSDF.R
   Class-STIDF.R Class-STTDF.R interval.R endtime.R ST-methods.R
   stinteraction.R

NeedsCompilation no

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Air quality data, rural background PM10 in Germany, daily averages 1998-2009

Description

Air quality data obtained from the airBase European air quality data base. Daily averages for rural background stations in Germany, 1998-2009. In addition, NUTS1 regions (states, or Bundeslaender) for Germany to illustrate spatial aggregation over irregular regions.

Usage

data(air)

Note

see vignette on overlay and spatio-temporal aggregation in this package; the vignette on using google charts shows where the ISO_3166_2_DE table comes from.
Author(s)

air quality data compiled for R by Benedict Graeler; NUTS1 level data obtained from https://www.gadm.org/

References

https://www.eionet.europa.eu/etcs/etc-acm/databases/airbase

Examples

data(air)
rural = STFDF(stations, dates, data.frame(PM10 = as.vector(air)))
# how DE was created from DE_NUTS1:
#if (require(rgdal))
# DE = gUnionCascaded(DE_NUTS1)
#

delta

Description

find default time interval end points when intervals are regular

Usage

delta(x)

Arguments

x object of class xts, or of another class that can be coerced into POSIXct

Details

to find the interval size for the last observation (which has no next observation), x needs to be at least of length 2.

Value

sequence of POSIXct time stamps, indicating the end of the time interval, given by the next observation in x. The last interval gets the same width of the one-but-last interval.

Author(s)

Edzer Pebesma
References

https://www.jstatsoft.org/v51/i07/

Examples

```r
x = as.POSIXct("2000-01-01") + (0:9) * 3600
delta(x)
```

---

**EOF**

_Note:_ This function computes spatial or temporal empirical orthogonal function (EOF) using the `prcomp` function from the base R package. For more details on `prcomp`, refer to its documentation.

**Description**

Compute spatial or temporal empirical orthogonal function (EOF)

**Usage**

```r
eof(x, how = c("spatial", "temporal"), returnEOFs = TRUE, ...)
EOF(x, how = c("spatial", "temporal"), returnPredictions = TRUE, ...)
```

**Arguments**

- `x`: object of class `STFDF`
- `how`: character; choose "spatial" or "temporal" mode
- `returnEOFs`: logical; if TRUE, the eigenvectors (EOFs) are returned in the form of a `Spatial` or `xts` object; if FALSE, the object returned by `prcomp` is returned, which can be printed, or from which a summary can be computed; see examples.
- `returnPredictions`: logical; if TRUE, the functions are returned (i.e., predicted principle components, or PC scores); if FALSE, the object returned by `prcomp` is returned, which can be printed, or from which a summary can be computed; see examples (deprecated, see below).
- `...`: arguments passed on to function `prcomp`; note that `scale.=TRUE` needs to be specified to obtain EOFs based on correlation (default: covariance)

**Value**

In spatial mode, the appropriate `Spatial*` object. In temporal mode, an object of class `xts`.

**Note**

`EOF` is deprecated: it mixes up spatial and temporal EOFs, and returns projections (PC scores) instead of EOFs (eigenvectors); to compute EOFs, use `eof`. 
```r
if (require(gstat)) {
  data(wind)
  library(sp)
  wind.loc$y = as.numeric(char2dms(as.character(wind.loc[["Latitude"]])))
  wind.loc$x = as.numeric(char2dms(as.character(wind.loc[["Longitude"]])))
  coordinates(wind.loc) = ~x+y
  proj4string(wind.loc) = "+proj=longlat +datum=WGS84"

  # match station order to names in wide table:
  stations = 4:15
  wind.loc = wind.loc[match(names(wind[stations]), wind.loc$Code),]
  row.names(wind.loc) = wind.loc$Station
  wind$time = ISOdate(wind$year+1900, wind$month, wind$day, 0)
  space = list(values = names(wind)[stations])
  wind.st = stConstruct(wind[stations], space, wind$time, SpatialObj = wind.loc)
  # select first 500 time steps, to limit run time:
  wind.st = wind.st[,1:500]
  wind.eof.1 = eof(wind.st)
  wind.eof.2 = eof(wind.st, "temporal")
  wind.eof.1.PCs = eof(wind.st, returnEOFs = FALSE)
  eof(wind.st, "temporal", returnEOFs = FALSE)
  summary(eof(wind.st, returnEOFs = FALSE))
  summary(eof(wind.st, "temporal", returnEOFs = FALSE))
  plot(eof(wind.st, "temporal", returnEOFs = FALSE))
}
```

---

**fires**  
*Northern Los Angeles County Fires*

**Description**  
Wildfire occurrences in Northern Los Angeles County, California between 1976 and 2000. The spatial units are in scaled feet, taken from the NAD 83 state-plane coordinate system. One unit is equivalent to 100,000 feet or 18.9 miles. The times for the points were produced by the date package and represent the number of days since January 1, 1960.

**Usage**  
data(fires)

**Format**  
A data frame with 313 observations with day of occurrence, x and y coordinates.
Author(s)

Roger Peng, taken from (non-CRAN) package ptproc,
https://www.biostat.jhsph.edu/~rpeng/software/index.html;
example code by Roger Bivand.

Examples

data(fires)
fires$X <- fires$X*100000
fires$Y <- fires$Y*100000
library(sp)
coordinates(fires) <- c("X", "Y")
proj4string(fires) <- CRS("+init=epsg:2229 +ellps=GRS80")
dates <- as.Date("1960-01-01")+(fires$Time-1)
Fires <- STIDF(as(fires, "SpatialPoints"), dates, data.frame(time=fires$Time))
library(mapdata)
if (require(sf)) {
m <- map("county", "california", xlim=c(-119.1, -117.5), ylim=c(33.7, 35.0), plot=FALSE, fill=TRUE)
m.sf <- st_transform(st_as_sfc(m), "EPSG:2229")
cc <- as(m.sf, "Spatial")
plot(cc, xlim=c(6300000, 6670000), ylim=c(1740000, 2120000))
plot(slot(Fires, "sp"), pch=3, add=TRUE)
stplot(Fires, sp.layout=list("sp.lines", cc))
}

mfn

Generic mnf method

Description

Compute mnf from spatial, temporal, or spatio-temporal data

Usage

mfn(x, ...)
## S3 method for class 'matrix'
mfn(x, ..., Sigma.Noise, use = "complete.obs")
## S3 method for class 'mts'
mfn(x, ..., use = "complete.obs")
## S3 method for class 'zoo'
mfn(x, ..., use = "complete.obs")
## S3 method for class 'SpatialPixelsDataFrame'
mfn(x, ..., use = "complete.obs")
## S3 method for class 'SpatialGridDataFrame'
mfn(x, ..., Sigma.Noise, use = "complete.obs")
## S3 method for class 'RasterStack'
mnf

```
mnf(x, ..., use = "complete.obs")
## S3 method for class 'RasterBrick'
mnf(x, ..., use = "complete.obs")
## S3 method for class 'STSDF'
mnf(x, ..., use = "complete.obs", mode = "temporal")
## S3 method for class 'STFDF'
mnf(x, ..., use = "complete.obs", mode = "temporal")
```

Arguments

- `x`: object for which an mnf method is available
- `...`: ignored
- `Sigma.Noise`: Noise covariance matrix; when missing, estimated from the data by using the covariance of lag-one spatial or temporal differences (MAF)
- `use`: method to deal with missing values when computing covariances; see `cov`
- `mode`: for ST objects: if "temporal", compute covariances in time dimension, if "spatial", compute them in spatial dimension.

Details

Uses MAF (Min/max Autocorrelation Factors) to estimate the noise covariance. This implementation estimates the noise covariance by $0.5 \text{Cov}(Z(s) - Z(s + \Delta))$, so that eigenvalues can be directly interpreted as approximate estimates of the noise covariance.

Value

object of class (c("mnf", "prcomp"); see `prcomp`. Additional elements are values, containing the eigenvalues.

See Also

- https://r-spatial.org/r/2016/03/09/MNF-PCA-EOF.html

Examples

# temporal data:
set.seed(13531) # make reproducible
s1 = arima.sim(list(ma = rep(1,20)), 500)
s2 = arima.sim(list(ma = rep(1,20)), 500)
s3 = arima.sim(list(ma = rep(1,20)), 500)
s3 = s3 + rnorm(500, sd = 10)
d = cbind(s1,s2,s3)
plot(d)
m = mnf(d)
m
summary(m)
plot(predict(m))

# spatial example:
## Not run:
na.locf

replace NA attribute values; disaggregation time series

Description

replace NA attribute values in time series, using last or next observation, or using (temporal) interpolation, and disaggregation

Usage
## S3 method for class 'STFDF'
na.locf(object, na.rm = FALSE, ...)
## S3 method for class 'STFDF'
na.approx(object, x = time(object), xout, ..., na.rm = TRUE)
## S3 method for class 'STFDF'
na.spline(object, x = time(object), xout, ..., na.rm = TRUE)

### Arguments
- **object**: object of class STFDF, with potentially NA values
- **na.rm**: logical; need non-replaced NA values be removed?
- **x**: times at which observations are taken; should not be modified
- **xout**: if present, new times at which the time series should be approximated (disaggregated)
- **...**: passed on to underlying zoo functions; see details

### Details
Details are found in `na.locf`, `na.approx`, `na.spline`.

### Value
Object of class STFDF, with NA values replaced.

### Author(s)
Edzer Pebesma

### References
https://www.jstatsoft.org/v51/i07/

### Examples
```
# toy example:
library(sp)
pts = SpatialPoints(cbind(c(0,1),c(0,1)))
Sys.setenv(TZ="GMT")
tm = seq(as.POSIXct("2012-11-25"), as.POSIXct("2012-11-30"), "1 day")
df = data.frame(a = c(NA,NA,2,3,NA,NA,NA,2,NA,NA,4,NA), b = c(NA,2,3,4,5,1,2,NA,NA,NA,3))
x = STFDF(pts, tm, df)
as(x, "xts")
as(na.locf(x), "xts")
as(na.locf(x, fromLast = TRUE), "xts")
as(na.locf(na.locf(x), fromLast = TRUE), "xts")
# drops first record:
as(na.approx(x[,1]), "xts")
# keep it:
cbind(as(na.approx(x[,1], na.rm = FALSE), "xts"),
as(na.approx(x[,2], na.rm = FALSE), "xts"))
```
cbind(as.na.spline(x[,1], "xts"),
as(na.spline(x[,2], "xts"))
#disaggregate:
xout = seq(start(x), end(x), "6 hours")
as(na.approx(x[,1], xout = xout), "xts")
as(na.spline(x[,1], xout = xout), "xts")
as(na.spline(x[,2], xout = xout), "xts")

# larger/real data:
data(air)
rural = STFDF(stations, dates, data.frame(PM10 = as.vector(air)))
# fill NA's with last non-NA
r = na.locf(rural)
# sample (NOT aggregate) to monthly:
m = seq(start(rural), end(rural), "1 month")
stplot(na.approx(rural[,1:20,"2003::2005"], xout = m), mode = 'ts')

---

### nbMult

**Description**

convert a spatial nb object to a matching STF object

**Usage**

```
nbMult(nb, st, addT = TRUE, addST = FALSE)
```

**Arguments**

- `nb`: object of class nb (see package spdep), which is valid for the spatial slot of object
- `st`: `length(nb)` should equal `length(st@sp)`
- `addT`: logical; should temporal neighbours be added?
- `addST`: logical; should spatio-temporal neighbours be added?

**Details**

if both `addT` and `addST` are false, only spatial neighbours are added for each time replicate.

details are found in


**Value**

object of class nb
Description
consistent spatio-temporal overlay for STF, STS and STI objects, as well as their *DF counterpart: retrieves the indexes or attributes from one geometry at the spatio-temporal points of another

Usage

```r
## S4 method for signature 'STF,STF'
over(x, y, returnList = FALSE, fn = NULL, ...)
## S4 method for signature 'xts,xts'
over(x, y, returnList = FALSE, fn = NULL, ...)
## S4 method for signature 'ST'
aggregate(x, by, FUN, ..., simplify = TRUE)
```

Arguments

- `x`: geometry (S/T locations) of the queries
- `y`: layer from which the geometries or attributes are queried
- `returnList`: logical; determines whether a list is returned, or an index vector
- `fn`: (optional) a function; see value
- `by`: geometry over which attributes in `x` are aggregated (this can be a Spatial* geometry, or a ST* geometry), or temporal aggregation, such as "month", "10 minutes", or a function such as `as.yearmon`; see `aggregate.zoo`. In case `x` is of class `STFDF`, argument `by` may be "time" or "space", in which cases aggregation over all time or all space is carried out.
- `FUN`: aggregation function
- `simplify`: boolean; if TRUE, and space or time dimensions can be dropped, the simpler (Spatial or `xts`) object will be returned
- `...`: arguments passed on to function `fn` or `FUN`

Value

an object of length `length(x)`, or a data.frame with number of rows equal to `length(x)`. If `returnList` is FALSE, a vector with indices of `y` for each geometry (point, grid cell centre, polygon or lines x time point) in `x`. If `returnList` is TRUE, a list of length `length(x)`, with list element `i` the vector of indices of the geometries in `y` that correspond to the `i`-th geometry in `x`.

The aggregate method for ST objects aggregates the attribute values of `x` over the geometry (space, time, or space-time) of `by`, using aggregation function `FUN`.

For the matching of time intervals, see `timeMatch`.

For setting, or retrieving whether time represents intervals, see `timeIsInterval`.
Methods

\( x = "STF", y = "STF" \)

\( x = "xts", y = "xts" \) finds the row index of the instance or interval of time instances of \( x \) matching to \( y \). Only if \( \text{timeIsInterval}(x) == \text{TRUE} \), intervals are sought. In that case, time intervals start at the time instance of a record, and end at the next. The last time interval length is set to the interval length of the one-but-last (non-zero) interval. In case of a single time instance for \( y \), its interval is right-open.

Note

See also over; methods intersecting SpatialLines with anything else, or SpatialPolygons with SpatialPolygons, need rgeos to be loaded first.

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

https://www.jstatsoft.org/article/view/v051i07

See Also

over; vignette('sto'), vignette('over'), timeMatch, timeIsInterval

---

**read.tgrass**

**read or write tgrass (time-enabled grass) files**

**Description**

read or write tgrass (time-enabled grass) files

**Usage**

```r
read.tgrass(fname, localName = TRUE, useTempDir = TRUE, isGeoTiff = TRUE)
write.tgrass(obj, fname, ...)
```

**Arguments**

- **fname** file name to read from, or write to
- **localName** logical; if \( \text{TRUE} \), \( \text{fname} \) is a local file, else it is a the full path name to the file
- **useTempDir** logical: use a temporary directory for extraction?
- **isGeoTiff** logical: are the files in the tar.gz file GeoTIFFs?
- **obj** object to export, of class STFDF or RasterStack
- **...** arguments passed on to writeRaster
Details
The tgrass format is a gzip'ed tar file (.tar.gz) that has geotiff files (with suffix .tif), and three files (list.txt, proj.txt and init.txt) describing the file names and time slices, coordinate reference system, and dimensions.

Value
read.tgrass returns an object of class RasterStack, writegrass returns nothing.

Author(s)
Edzer Pebesma; time-enabled grass by Soeren Gebbert.

References
https://dx.doi.org/10.1016/j.envsoft.2013.11.001

Examples
## Not run:
library(spacetime)
r = read.tgrass("precipitation_1950_2011_yearly.tar.gz", useTempDir = FALSE)
write.tgrass(r, "myfile.tar.gz")
## End(Not run)

ST-class

Class "ST"

Description
An abstract class from which useful spatio-temporal classes are derived.

Usage
ST(sp, time, endTime)

Arguments
sp an object deriving from class Spatial, such as a SpatialPoints or SpatialPolygons

time an object of class xts, or a time vector (currently: Date, POSIXct, timeDate, yearmon and yearqtr; are supported; see xts); in the latter case, it should be in time order

endTime vector of class POSIXct holding end points of time intervals

Objects from the Class
Objects of this class are not meant to be useful; only derived classes can be meaningful.
Slots

sp: Object deriving from class "Spatial"

time: Object of class "xts"

Methods

[[ signature(obj = "ST"): retrieves the attribute element

$ signature(obj = "ST"): retrieves the attribute element

[[<- signature(obj = "ST"): sets or replaces the attribute element

$<- signature(obj = "ST"): sets or replaces the attribute element

Note

argument (and object slot) sp can be pure geometry, or geometry with attributes. In the latter case, the geometries are kept with the sp slot, and only replicated (when needed) on coercion to the long format, with as.data.frame.

Slot time needs to be of class xts; if a time or date vector is passed as argument to SP, it will be converted into an xts object.

When endTime is missing, an error is thrown.

ST is meant as a super-class, and is not to be used for representing data, similar to Spatial in the sp package.

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

https://www.jstatsoft.org/v51/i07/

Examples

time = as.Date('2008-01-01')+1:2
library(sp)
sp = SpatialPoints(cbind(c(0,1),c(0,1)))
ST(sp, time, delta(time))
stbox

Description
obtain ranges of space and time coordinates

Usage
stbox(obj)
bbox(obj)

Arguments
obj object of a class deriving from ST

Value
stbox returns a data.frame, with three columns representing x-, y- and time-coordinates, and two rows containing min and max values. bbox gives a matrix with coordinate min/max values, compatible to bbox

Methods
stbox signature(x = "ST"): obtain st range from object

stConstruct
create ST* objects from long or wide tables

Description
create ST* objects from long or wide tables

Usage
stConstruct(x, space, time, SpatialObj = NULL, TimeObj = NULL, crs = CRS(as.character(NA)), interval, endTime)
Arguments

x          object of class matrix or data.frame, holding the long, space-wide or time-wide table; see details.
space      in case x is a long table, character or integer holding the column index in x where the spatial coordinates are (if length(space)==2) or where the ID of the spatial location is (if (length(space)==1). If x is a space-wide table, a list with each (named) list element a set of columns that together form a variable
time       in case x is a long table, character or integer indicating the column in x with times;
SpatialObj object of class Spatial-class, containing the locations of a time-wide table, or the locations of a long table
TimeObj    in case of space-wide table, object of class xts, containing the times for each of the columns in a list element of space
crs        object of class CRS-class; only used when coordinates are in x and no CRS can be taken from SpatialObj
interval   logical; specifies whether time should reflect time instance (FALSE) or time intervals (TRUE). If omitted, defaults values depend on the class
endTime    vector of POSIXct, specifying (if present) the end points of observation time intervals

Details

For examples, see below.

A long table is a data.frame with each row holding a single observation in space-time, and particular columns in this table indicate the space (location or location ID) and time.

A space-wide table is a table in which different columns refer to different locations, and each row reflects a particular observation time.

A time-wide table is a table where different times of a particular characteristic are represented as different columns; rows in the table represent particular locations or location IDs.

Value

Depending on the arguments, an object of class STIDF or STFDF.

References

https://www.jstatsoft.org/v51/i07/

Examples

# stConstruct multivariable, time-wide
if (require(maps) && require(plm) && require(sf)) {
  library(sp)

  states.m <- map('state', plot=FALSE, fill=TRUE)
  IDs <- sapply(strsplit(states.m$names, ":"), function(x) x[1])
sf = st_as_sf(states.m, IDs=IDs)
row.names(sf) = sf$ID # not needed if sf >= 1.0-13
states <- as(sf, "Spatial")
states=geometry(states)

yrs = 1970:1986
time = as.POSIXct(paste(yrs, "-01-01", sep=""), tz = "GMT")
data("Produc")

# deselect District of Columbia, polygon 8, which is not present in Produc:
Produc.st <- STFDF(states[-8], time, Produc[order(Produc[,2], Produc[,1]),])
# stplot(Produc.st[,,"unemp"], yrs, col.regions = brewer.pal(9, "YlOrRd"), cuts=9)

# example 1: st from long table, with states as Spatial object:
# use Date format for time:
Produc$time = as.Date(paste(yrs, "01", "01", sep = "-"))
# take centroids of states:
xy = coordinates(states[-8])
Produc$x = xy[,1]
Produc$y = xy[,2]
# using stConstruct, use polygon centroids for location:
x = stConstruct(Produc, c("x", "y"), "time", interval = TRUE)
class(x)
stplot(x[,"unemp"],)

# alternatively, pass states as SpatialObj:
Produc$state = gsub("TENNESSE", "TENNESSEE", Produc$state)
Produc$State = gsub("_", " ", tolower(Produc$state))
x = stConstruct(Produc, "State", "time", states)
class(x)
all.equal(x, Produc.st, check.attributes = FALSE)

if (require(sf)) {
fname = system.file("shape/nc.shp", package="sf")[1]
nc = as(st_read(fname), "Spatial")
timesList = list(
  BIR=c("BIR74", "BIR79"), # sets of variables that belong together
  NWBIR=c("NWBIR74", "NWBIR79"), # only separated by space
  SID=c("SID74", "SID79")
)
t = as.Date(c("1974-01-01", "1979-01-01"))
nc.st = stConstruct(as(nc, "data.frame"), geometry(nc), timesList, TimeObj = t, interval = TRUE)
}

# stConstruct multivariable, space-wide
if (require(gstat)) {
data(wind)
wind.loc$y = as.numeric(char2dms(as.character(wind.loc["Latitude"])))
wind.loc$x = as.numeric(char2dms(as.character(wind.loc["Longitude"])))
coordinates(wind.loc) = ~x+y
proj4string(wind.loc) = "+proj=longlat +datum=WGS84"
# match station order to names in wide table:
stations = 4:15
wind.loc = wind.loc[match(names(wind[stations]), wind.loc$Code),]
row.names(wind.loc) = wind.loc$Station

# convert to utm zone 29, to be able to do interpolation in
# proper Euclidian (projected) space:

# create time variable
wind$time = ISOdate(wind$year+1900, wind$month, wind$day, 0)

w = STFDF(wind.loc, wind$time,
data.frame(values = as.vector(t(wind[stations])))
space = list(values = names(wind)[stations])
wind.st = stConstruct(wind[stations], space, wind$time, SpatialObj = wind.loc, interval = TRUE)
all.equal(w, wind.st)
class(wind.st)
}

---

**STFDF-class**

**Class “STFDF”**

**Description**

A class for spatio-temporal data with full space-time grid; for n spatial locations and m times, n x m observations are available

**Usage**

```r
STF(sp, time, endTime = delta(time))
STFDF(sp, time, data, endTime = delta(time))
## S4 method for signature 'STFDF'
x[i, j, ..., drop = is(x, "STFDF")]
## S4 method for signature 'STFDF,xts'
coerce(from, to, strict=TRUE)
## S4 method for signature 'STFDF,Spatial'
coerce(from, to)
```

**Arguments**

- `sp`: object of class `Spatial`, having n elements
- `time`: object holding time information, of length m; see `ST` for details
- `endTime`: vector of class POSIXct, holding end points of time intervals; by default, time intervals equal the time step width, see `delta`
- `data`: data frame with n*m rows corresponding to the observations (spatial index moving fastest)
- `x`: an object of class STFDF
- `i`: selection of spatial entities
j          selection of temporal entities (see syntax in package xts)

...        selection of attribute(s)

drop       if TRUE and a single spatial entity is selected, an object of class xts is returned;
if TRUE and a single temporal entity is selected, an object of the appropriate Spatial class is
returned; if FALSE, no coercion to reduced classes takes place

from       object of class STFDF

to          target class

strict     ignored

Value

the as.data.frame coercion returns the full long table, with purely spatial attributes and purely
time attributes replicated appropriately.

Objects from the Class

Objects of this class represent full space/time data with a full grid (or lattice) layout

Slots

sp:  spatial object; see ST-class

time: temporal object; see ST-class

data: Object of class data.frame, which holds the measured values; space index cycling first,
time order preserved

Methods

[ signature(x = "STFDF"): selects spatial entities, temporal entities, and attributes

coerce   STFDF,xts

coerce   STFDF,Spatial(from) coerces to (wide form) SpatialXxDataFrame, where SpatialXx is the
spatial class of from@sp

plot   signature(x = "STF", y = "missing"): plots space-time layout

plot   signature(x = "STFDF", y = "missing"): plots space-time layout, indicating full missing
valued records

Author(s)

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

References

https://www.jstatsoft.org/v51/i07/
**Examples**

```r
sp = cbind(x = c(0, 0, 1), y = c(0, 1, 1))
row.names(sp) = paste("point", 1:nrow(sp), sep="")
library(sp)
sp = SpatialPoints(sp)
time = as.POSIXct("2010-08-05") + 3600*(10:13)
m = c(10, 20, 30) # means for each of the 3 point locations
mydata = rnorm(length(sp)*length(time), mean=rep(m, 4))
IDs = paste("ID", 1:length(mydata))
mydata = data.frame(values = signif(mydata,3), ID=IDs)
stfdf = STFDF(sp, time, mydata)
```

```r
stfdf[1:2,]
stfdf[,1:2]
stfdf[, ,2]
stfdf[, ,"values"]
stfdf[1,]
stfdf[1, ,2]
as(stfdf[1,], "xts")
as(stfdf[, 2], "xts")
# examples for [[, [<-, $ and $<-
```

```r
stfdf[1:13]
stfdf["values"]
stfdf["newVal"] <- rnorm(12)
```

```r
stfdf$ID
stfdf$ID = paste("OldIDs", 1:12, sep="")
```

```r
stfdf$NewID = paste("NewIDs", 12:1, sep="")
```

```r
stfdf x = stfdf[stfdf[1:2,],]
all.equal(x, stfdf[1:2,])
all.equal(stfdf, stfdf[stfdf,]) # converts character to factor...
```

---

**STIDF-class**

Class "STIDF"

**Description**

A class for unstructured spatio-temporal data; for n spatial locations and times, n observations are available

**Usage**

```r
STI(sp, time, endTime)
STIDF(sp, time, data, endTime)
## S4 method for signature 'STIDF'
x[i, j, ...]
## S4 method for signature 'STIDF,STSDF'
coerce(from, to, strict=TRUE)
```
**STIDF-class**

**Arguments**

- **sp**: object of class `Spatial`
- **time**: object holding time information; when STIDF is called, a non-ordered vector with times, e.g. `POSIXct` will also work, and rearrange the `sp` and `data` slots according to the ordering of time; for this to work no ties should exist.
- **endTime**: vector of class `POSIXct`, indicating the end points of time intervals for the observations. By default, for `STI` objects `time` is taken, indicating that time intervals have zero width (time instances)
- **data**: data frame with appropriate number of rows
- **x**: an object of class `STFDF`
- **i**: selection of record index (spatial/temporal/spatio-temporal entities)
- **j**: or character string with temporal selection
- **drop**: if `TRUE` and a single spatial entity is selected, an object of class `xts` is returned (NOT yet implemented); if `TRUE` and a single temporal entity is selected, and object of the appropriate `Spatial` class is returned; if `FALSE`, no coercion to reduced classes takes place
- **from**: object of class `STFDF`
- **to**: target class
- **strict**: ignored

**Objects from the Class**

Objects of this class carry full space/time grid data

**Slots**

- **sp**: Object of class "Spatial"
- **time**: Object holding time information, see `ST-class`
- **data**: Object of class `data.frame`, which holds the measured values

**Methods**

- `[ signature(x = "STIDF")`: selects spatial-temporal entities, and attributes

**Note**

arguments `sp`, `time` and `data` need to have the same number of records, and regardless of the class of time (xts or POSIXct) have to be in corresponding order: the triple `sp[i], time[i]` and `data[i,]` refer to the same observation

**Author(s)**

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>
stInteraction

subtract marginal (spatial and temporal) means from observations

Usage

stInteraction(x, ...)

Arguments

x object of class STFDF

... arguments passed to rowMeans, colMeans and mean, such as na.rm=TRUE

Value

object of class STFDF with each attribute replaced by its residual, computed by $y_{ij} = x_{ij} - m_j m_i / m$ with $m$ the grand mean, $m_j$ the temporal mean, $m_i$ the spatial mean and $m$ the grand mean.

Examples

if (require(gstat)) {
  library(sp)
  data(wind)
  wind.loc$y = as.numeric(char2dms(as.character(wind.loc[["Latitude"]])))
}
wind.loc$x = as.numeric(char2dms(as.character(wind.loc[["Longitude"]])))
coordinates(wind.loc) = ~x+y
proj4string(wind.loc) = "+proj=longlat +datum=WGS84"
# match station order to names in wide table:
stations = 4:15
wind.loc = wind.loc[match(names(wind[stations]), wind.loc$Code),]
row.names(wind.loc) = wind.loc$Station
wind$time = ISOdate(wind$year+1900, wind$month, wind$day, 0)
space = list(values = names(wind)[stations])
wind.st = stConstruct(wind[stations], space, wind$time, SpatialObj = wind.loc)
wind.sti = stInteraction(wind.st)
# temporal means for any station should be zero:
c(mean(wind.sti[3,]),)
# spatial mean for each time step should be zero:
mean(wind.sti[,5][[1]])
}

---

stplot

produce trellis plot for STxDF object

Description

create trellis plot for ST objects

Usage

stplot(obj, ...)
stplot.STDFDF(obj, names.attr = trimDates(obj), ..., as.table = TRUE, at, cuts = 15, scales = list(draw = FALSE), animate = 0, mode = "xy", scaleX = 0, auto.key = list(space = key.space), main, key.space = "right", type = "l", do.repeat = TRUE, range.expand = 0.001)
stplot.STIDF(obj, ..., names.attr = NULL, as.table = TRUE, scales = list(draw = FALSE), xlab = NULL, ylab = NULL, type = "p", number = 6, tcuts, sp.layout = NULL, xlim = bbox(obj)[1, ], ylim = bbox(obj)[2, ])

Arguments

obj object of a class deriving from ST
names.attr names that will be used in the strip; trimDates(obj) trims "-01" ending(s) from printed Dates
as.table logical: if TRUE, time will increas from top to bottom; if FALSE, time will increase from bottom to top
at values at which colours will change; see levelplot
cuts  number of levels the range of the attribute would be divided into
animate numeric; if larger than 0, the number of seconds between subsequent animated
time steps (loop; press ctrl-C or Esc to stop)
mode  plotting mode; if "xy", maps for time steps are plotted; if "xt", a space-time plot
       is constructed (see argument scaleX, but read details below); if "ts", multiple-
       locations time series are plotted in a single plot, or in a separate panel for each
       attribute; if "tp" single- or multi-attribute time series are plotted in multiple pan-
       els, one panel per location.
scaleX integer: 0, 1 or 2; when mode is "xt", used to determine whether the index of the
       spatial location is shown (0), the x coordinate (1) or the y coordinate (2).
auto.key see the auto.key argument in xyplot
main character; plot title, use NULL to omit title
key.space character; see xyplot
scales scales drawing; see scales argument of xyplot
xlab x-axis label
ylab y-axis label
type character; use 'l' for lines, 'p' for symbols, 'b' for both lines and symbols
do.repeat logical; repeat the animation in an infinite loop?
rangexpand numeric; if at is not specified, expand the data range with this factor to cover
       all values
number number of time intervals, equally spaced
tcuts  time cuts in units of index(obj); this overrides number
sp.layout list or NULL; see spplot
... arguments passed on to spplot in case of plotting objects of class STFDF or
       STIDF, or to xyplot in case of stplot.STIDF
xlim numeric, x range
ylim numeric, y range

Value

In non-animation and "xy" mode, stplot is a wrapper around spplot, that automatically plots each
time stamp in a panel. The returned value is is a lattice plot.

In "xt" mode, a space-time plot with space on the x-axis and time on the y-axis is plotted. By
default, the space ID is plotted on the x-axis, as space can be anything (points, polygons, grid cells
etc). When scaleX is set to 1 or 2, the x- resp. y-coordinates of the spatial locations, obtained by
coordinates, is used instead. Beware: when the x-coordinate is plotted, and for each (x,t) element
multiple y-coordinates are sent to the plot, it is not clear which (x,y,t) value becomes the plotted
value, so slicing single y values is advised – no checking is done. The returned value is is a lattice
plot.

In animation mode (animate > 0), single maps are animated in an endless loop, with animate
seconds between each. No proper value is returned: the loop needs to be interrupted by the user.
Methods

stplot signature(x = "STFDF"): plots object of class STFDF
stplot signature(x = "STSDF"): plots object of class STSDF
stplot signature(x = "STI"): plots object of class STI
stplot signature(x = "STIDF"): plots object of class STIDF
stplot signature(x = "STT"): plots object of class STT
stplot signature(x = "STTDF"): plots object of class STTDF

Note

vignette("spacetime") contains several examples

References

https://www.jstatsoft.org/v51/i07/

---

STSDF-class

Class "STSDF"

Description

A class for spatio-temporal data with partial space-time grids; for n spatial locations and m times, an index table is kept for which nodes observations are available

Usage

STS(sp, time, index, endTime = delta(time))
STSDF(sp, time, data, index, endTime = delta(time))

## S4 method for signature 'STSDF'
x[i, j, ..., drop = is(x, "STSDF")]

## S4 method for signature 'STSDF,STFDF'
coerce(from, to, strict=TRUE)

## S4 method for signature 'STSDF,STIDF'
coerce(from, to, strict=TRUE)

Arguments

sp object of class Spatial
time object holding time information; see ST-class
data data frame with rows corresponding to the observations (spatial index moving faster than temporal)
index two-column matrix: rows corresponding to the nodes for which observations are available, first column giving spatial index, second column giving temporal index
**endTime**  
vector of class POSIXct with end points of time intervals for the observations

**x**  
an object of class STFDF

**i**  
selection of spatial entities

**j**  
selection of temporal entities (see syntax in package xts)

**drop**  
if TRUE and a single spatial entity is selected, an object of class xts is returned; if TRUE and a single temporal entity is selected, and object of the appropriate Spatial class is returned; if FALSE, no coercion to reduced classes takes place

**from**  
oject of class STFDF

**to**  
target class

**strict**  
ignored

**Objects from the Class**

Objects of this class carry sparse space/time grid data

**Slots**

- **sp**: Object of class "Spatial"
- **time**: Object holding time information; see ST-class for permitted types
- **index**: matrix of dimension n x 2, where n matches the number of rows in slot data
- **data**: Object of class data.frame, which holds the measured values

**Methods**

- **[ signature(x = "STSDF")**: selects spatial entities, temporal entities, and attributes
- **plot signature(x = "STS", y = "missing")**: plots space-time layout
- **plot signature(x = "STSDF", y = "missing")**: plots space-time layout, indicating records partially NA

**Author(s)**

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

**References**

https://www.jstatsoft.org/v51/i07/

**See Also**

delta
Examples

sp = cbind(x=c(0,0,1), y=c(0,1,1))
row.names(sp) = paste("point", 1:nrow(sp), sep="")
library(sp)
sp = SpatialPoints(sp)
library(xts)
time = xts(1:4, as.POSIXct("2010-08-05")+3600*(10:13))
m = c(10,20,30) # means for each of the 3 point locations
mydata = rnorm(length(sp)*length(time), mean=rep(m, 4))
IDs = paste("ID",1:length(mydata))
mydata = data.frame(values = signif(mydata,3), ID=IDs)
stfdf = STFDF(sp, time, mydata)
stfdf
stsdf = as(stfdf, "STSDF")
stsdf[1:2,]
stsdf[,1:2]
stsdf[,2]
stsfdf[,]"values"
stsdf[1,]
stsfdf[2,]

# examples for [[, [[<-, $ and $<-
stsfdf[[1]]
stsfdf["values"]
stsfdf["newVal"] <- rnorm(12)
stsfdf$ID
stsdf$ID = paste("OldIDs", 1:12, sep="")
stsfdf$NewID = paste("NewIDs", 12:1, sep="")
stsdf
x = stsdf[stsdf,]
x = stsdf[stsdf[1:2,],]
all.equal(x, stsdf[1:2,])

STTDF-class

Class "STTDF"

Description

A class for spatio-temporal trajectory data

Usage

## S4 method for signature 'STTDF,ltraj'
coerce(from, to, strict=TRUE)

## S4 method for signature 'ltraj,STTDF'
coerce(from, to, strict=TRUE)

Arguments

from from object
to target class
strict ignored

**Objects from the Class**

Objects of this class carry sparse (irregular) space/time data

**Slots**

- sp: Object of class "Spatial", containing the bounding box of all trajectories
- time: Object of class "xts", containing the temporal bounding box of all trajectories
- traj: Object of class list, each element holding an STI object reflecting a single trajectory;
- data: Object of class data.frame, which holds the data values for each feature in each trajectory

**Methods**

- signature(x = "STTDF"): select trajectories, based on index, or spatial and/or temporal predicates

**Note**

The data.frame needs to have a column called `burst` which is a factor (or character) and contains the grouping of observations that come from a continuous sequence of observations. In addition, a column `id` is used to identify individual items.

**Author(s)**

Edzer Pebesma, <edzer.pebesma@uni-muenster.de>

**References**

https://www.jstatsoft.org/v51/i07/

**Examples**

```r
library(sp)
m = 3  # nr of trajectories
n = 100  # length of each
l = vector("list", m)
t0 = as.POSIXct("2013-05-05", tz="GMT")
set.seed(1331)  # fix randomness
for (i in 1:m) {
  x = cumsum(rnorm(n))
  y = cumsum(rnorm(n))
  sp = SpatialPoints(cbind(x, y))
  t = t0 + (0:(n-1) + (i-1)*n) * 60
  l[[i]] = STI(sp, t)
}
stt = STT(l)
```
timeIsInterval

retrieve, or set, information whether time reflects instance (FALSE) or intervals (TRUE)

Description
retrieve, or set, information whether time reflects instance (FALSE) or intervals (TRUE)

Usage
timeIsInterval(x, 

Arguments
x object, of any class

value logical; sets the timeIsInterval value

Value
logical; this function sets or retrieves the attribute timeIsInterval of x, UNLESS x is of class ST, in which case it sets or retrieves this attribute for the time slot of the object, i.e. timeIsInterval(x@time) <- value
Note

From spacetime 0.8-0 on, timeIsInterval is dropped in favour of a more generic time intervals by specifying endTime of each observation

See Also

over, timeIsInterval

timeMatch

match two (time) sequences

Description

match two (time) sequences, where each can be intervals or instances.

Usage

```r
timeMatch(x, y, returnList = FALSE, ...)
```

Arguments

- `x` ordered sequence, e.g. of time stamps
- `y` ordered sequence, e.g. of time stamps
- `returnList` boolean; should a list be returned with all matches (TRUE), or a vector with single matches (FALSE)?
- `...` end.x and end.y can be specified for xts and POSIXct methods

Details

When `x` and `y` are of class xts or POSIXct, end.x and end.y need to specify endpoint of intervals. In case `x` and `y` are both not intervals, matching is done on equality of values, using `match`.

If `x` represents intervals, then the first interval is from `x[1]` to `x[2]`, with `x[1]` included but `x[2]` not (left-closed, right-open). In case of zero-width intervals (e.g. `x[1]==x[2]`), nothing will match and a warning is raised. Package intervals is used to check overlap of intervals, using `interval_overlap`.

Value

- if `returnList = FALSE`: integer vector of length `length(x)` with indexes of `y` matching to each of the elements of `x`, or NA if there is no match. See section details for definition of match.
- if `returnList = TRUE`: list of length `length(x)`, with each list element an integer vector with all the indexes of `y` matching to that element of `x`. 
timeMatch

Author(s)
Edzer Pebesma

References
https://www.jstatsoft.org/v51/i07/

See Also
over, timeIsInterval, interval_overlap

Examples

t0 = as.POSIXct("1999-10-10")
x = t0 + c(0.5 + c(2, 2.1, 4), 5) * 3600
y = t0 + 1.5 * 3600
x
y
# timeIsInterval(x) = FALSE
# timeIsInterval(y) = FALSE
timeMatch(x, y, returnList = FALSE)
timeMatch(x, y, returnList = TRUE)
# timeIsInterval(x) = TRUE
timeMatch(x, y, returnList = FALSE, end.y = delta(y))
timeMatch(x, y, returnList = TRUE, end.y = delta(y))
# timeIsInterval(x) = TRUE
timeMatch(x, y, returnList = FALSE, end.x = delta(x), end.y = delta(y))
timeMatch(x, y, returnList = TRUE, end.x = delta(x), end.y = delta(y))
# timeIsInterval(y) = FALSE
timeMatch(x, y, returnList = FALSE, end.x = delta(x))
timeMatch(x, y, returnList = TRUE, end.x = delta(x))

x = as.POSIXct("2000-01-01") + (0:9) * 3600
y = x + 1
x
y
TI = function(x, ti) {
  timeIsInterval(x) = ti
  x
}
  # timeMatch(TI(y, FALSE), TI(y, FALSE))
  # timeMatch(TI(y, TRUE), TI(y, TRUE))
  # timeMatch(TI(x, FALSE), TI(y, FALSE))
  # timeMatch(TI(x, FALSE), TI(y, TRUE))
  # timeMatch(TI(x, TRUE), TI(y, FALSE))
  # timeMatch(TI(x, TRUE), TI(y, TRUE))
    # timeMatch(TI(x, FALSE), TI(y, FALSE), returnList = TRUE)
    # timeMatch(TI(x, FALSE), TI(y, TRUE), returnList = TRUE)
    # timeMatch(TI(x, TRUE), TI(y, FALSE), returnList = TRUE)
}
unstack write STFDF to table forms

Description
create table forms of STFDF objects

Usage

## S3 method for class 'STFDF'
unstack(x, form, which = 1, ...)
## S3 method for class 'STFDF'
as.data.frame(x, row.names, ...)

Arguments

x object of class STFDF
form formula; can be omitted
which column name or number to have unstacked
row.names row.names for the data.frame returned
... arguments passed on to the functions unstack or as.data.frame

Value
unstack returns the data in wide format, with each row representing a spatial entity and each column a time; see unstack for details and default behaviour.
as.data.frame returns the data.frame in long format, where the coordinates of the spatial locations (or line starting coordinates, or polygon center points) and time stamps are recycled accordingly.

Examples

sp = cbind(x = c(0,0,1), y = c(0,1,1))
row.names(sp) = paste("point", 1:nrow(sp), sep="")
library(sp)
sp = SpatialPoints(sp)
library(xts)
time = xts(1:4, as.POSIXct("2010-08-05")+3600*(10:13))
m = c(10,20,30) # means for each of the 3 point locations
mydata = rnorm(length(sp)*length(time),mean=rep(m, 4))
IDs = paste("ID",1:length(mydata))
mydata = data.frame(values = signif(mydata,3), ID=IDs)
stfdf = STFDF(sp, time, mydata)
as.data.frame(stfdf, row.names = IDs)
unstack

unstack(stfdf)
t(unstack(stfdf))
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