Package 'ursa'

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Type Package

Title Non-Interactive Spatial Tools for Raster Processing and Visualization

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Description S3 classes and methods for manipulation with georeferenced raster data: reading/writing, processing, multi-panel visualization.

License GPL (>= 2)

URL https://github.com/nplatonov/ursa

BugReports https://github.com/nplatonov/ursa/issues

Depends R (>= 4.1.0)

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Description

Have a great work with **ursa**!

Details

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Author(s)

Nikita Platonov <platonov@sevin.ru>

`allocate` *Rasterization of point data into grid cells*

Description

`allocate` takes `x` and `y` coordinates and values from data frame, which is describing point spatial data, and puts them into cells of raster. The certain function (either mean value, sum of values, number of points) is applied for >0 points inside of the exact cell borders.

Usage

```
allocate(vec, coords = c("x", "y"), nodata = NA, attr = ".+",
         fun = c("mean", "sum", "sd", "n"), cellsize = NA, resetGrid = FALSE,
         verbose = FALSE)
```

Arguments

vec	data.frame. At least x and y should be in colnames(vec). Is is allowed to use "SpatialPointsDataFrame" from package **sp**. The "on the fly" reprojection is not supported.
coords	Character of length 2. Colums names, which contain coordinates of data points. Raster bands are not produced for specified columns. For misreference of coordinate columns, the attempt to find more appropriate coordinate columns is taken.
fun	Character keyword of function, which is applied to value of points, which are dropped into the same cell. Valid values are "mean" (mean value), "sum" (sum of values), "sd" (standard deviation), "n" (number of points).
nodata	Numeric of length 1. This value used to mark NA values in the writing to file.
attr	Pattern in the format of regular expressions, which is used to select required columns in data frame. By default (".*") all columns are used.
cellsize	Numeric. Desired size of cell in the raster grid. Used only when source data are not in regular grid. Default is NA; cell size is determined automatically to exclude case of points overlapping.
resetGrid	Logical. If TRUE then existing base grid (from session_grid()) will be overwritten. Otherwise using of current grid will be attempted.
verbose	Logical. Some output in console. Primarily for debug purposes.

Details

Here fun differs from R-styled fun in such functions as *apply, aggregate.

It was refused "rasterize" for function name to distinguish with rasterize in the package **raster**

Value

Object of class ursaRaster

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
g1 <- session_grid(regrid(session_grid(),mul=1/10))
n <- 1000
x <- with(g1,runif(n,min=minx,max=maxx))
y <- with(g1,runif(n,min=miny,max=maxy))
z <- with(g1,runif(n,min=0,max=10))
da <- data.frame(x=x,y=y,value=z)
res <- c(mean=allocate(da,fun="mean")
        ,mean_=NA
        ,sum=allocate(da,fun="sum")
        ,count=allocate(da,fun="n"))
```

```
res["mean_"]=res["sum"]/res["count"]
print(res)
```

`as.array` *Export raster object to multidimensional array*

Description

In the `ursaRaster` object the 3-dimensional image data are presented in 2-dimensional matrix. `as.array` transforms internal 2-dimensional data to the usual 3-dimansional data. `as.matrix` just extracts image data in internal 2-dimensional format.

Usage

```
## S3 method for class 'ursaRaster'
as.array(x, ...)

## non-public
.as.array(x, drop = FALSE, flip = FALSE, permute = FALSE, dim = FALSE)
```

Arguments

`...`	Arguments, which are passed to `.as.array`.
`x`	`ursaRaster` object
`drop`	Logical. If `drop=TRUE` then single-band images are presented without third dimension.
`permute`	Logical. If `permute=FALSE` then returned array has dimension *(samples, lines, bands)*. If `permute=TRUE` then returned array has dimension *(lines, samples, bands)*.
`flip`	Logical. If `flip=TRUE` then vertical flip (reverse coordinates for dimension #2) is applied for output image.
`dim`	Logical. If `dim=TRUE` then array's dimension is returned.

Details

Use `permute=TRUE` to create an object of class `raster`: `as.raster(as.array(...))`

The spatial reference system is lost.

Value

If `dim=FALSE` then `as.array` returns object of class `array`.
If `dim=TRUE` then `as.array` returns dimension of array.
`as.matrix` returns object of class `matrix`.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

as.raster is a function to direct export to the object of class raster.
as.matrix with argument/value coords=TRUE and as.data.frame for object of class ursaRaster keep spatial reference system.

Examples

```
session_grid(NULL)
a <- pixelsize()
a <- (a-global_min(a))/(global_max(a)-global_min(a))
b <- c(entire=a,half=a/2,double=a*2)
str(m <- as.matrix(b))
str(d1 <- as.array(b))
str(d2 <- as.array(b[1],drop=FALSE))
str(d3 <- as.array(b[1],drop=TRUE))
contour(d3)
filled.contour(d3)
d4 <- as.array(b,perm=TRUE)/global_max(b)
d4[is.na(d4)] <- 0
str(d4 <- as.raster(d4))
plot(d4)
```

---

as.data.frame *Convert raster image to a data frame*

Description

as.data.frame reorganizes ursaRaster object into data frame, where first two columns (x and y) are coordinates of cells, and the rest columns are cell values.

Usage

```
## S3 method for class 'ursaRaster'
as.data.frame(x, ...)

# non-public
.as.data.frame(obj, band = FALSE, id = FALSE, na.rm = TRUE, all.na = FALSE,
               col.names = NULL)
```

Arguments

x, obj	Object of class ursaRaster
...	Set of arguments, which are recognized via their names (using regular expressions) and classes. Passed to non-public .as.data.frame.

Pattern (as.data.frame) **Argument** (.as.data.frame) **Description**

band	band	*See below*.
id	id	*See below*.
na\\.rm	na.rm	*See below*.
all\\.na	all.na	*See below*.
col(\\.)*name(s)*	col.names	*See below*.

band — Logical. If band=FALSE then each band is presented by separate column in the data frame. If band=TRUE then band name is presented as a factor in the column $band, and values are written in the column $z. If band=TRUE then number of rows is

id — Logical. If band=FALSE then is ignored. If id=TRUE then addiditional columns $id will contain unique cell number in the source raster.

na.rm — Logical. If na.rm=FALSE then number of rows for data frame is equal to number of cells of spatial grid of raster. If na.rm=TRUE then cells with 'no data' values for all (all.na=FALSE) or any (all.na=TRUE) bands are omitted.

all.na — Logical. If na.rm=FALSE then ignored. If number of rows for data frame is equal to number of cells of spatial grid of raster. If na.rm=TRUE then cells with 'no data' values for all bands are omitted.

col.names — Character vector or NULL. Names for columns of data frame. If NULL, then column names are generated from band names. Default is NULL.

Details

The structure of voxel is kept. The number of rows for band=TRUE is equal to the number of rows for band=FALSE multiplied to number of bands. To extract all numeric data with destroying of voxel, you may use followed code:
subset(as.data.frame(obj,band=TRUE),!is.na(z)).

Value

Data frame.

If band=TRUE then

x — Horizontal coordinate of cell's midpoint

y — Vertical coordinate of cell's midpoint

z — Value

band — Band as a factor

id — *Optional*. Unique number for (x,y) coordinate.

If band=FALSE then

x — Horizontal coordinate of cell's midpoint

y — Vertical coordinate of cell's midpoint

... — Additional columns. Names of columns are names of bands. Values of columns are values of corresponded bands.

If ursaRaster is projected, then data frame has additional attribute attr(...,"proj") with value of PROJ.4 string.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
session_grid(regrid(res=50000,lim=c(-1200100,-1400800,1600900,1800200)))
a0 <- ursa_dummy(nband=3,min=0,max=100)
a0[a0<30 | a0>70] <- NA
names(a0) <- c("x","y","z")
print(a0)
b0 <- as.data.frame(a0)
session_grid(NULL)
a1 <- as.ursa(b0)
print(a1-a0)
session_grid(NULL)
session_grid(regrid(res=5800000))
set.seed(352)
a2 <- as.integer(ursa_dummy(nband=2,min=0,max=100))
a2[a2>50] <- NA
print(a2)
print(b1 <- as.data.frame(a2,na.rm=FALSE))
print(b2 <- as.data.frame(a2,na.rm=TRUE))
print(b3 <- as.data.frame(a2,all.na=TRUE))
print(b4 <- as.data.frame(a2,band=TRUE,na.rm=FALSE))
print(b5 <- as.data.frame(a2,band=TRUE,all.na=FALSE))
print(b6 <- as.data.frame(a2,band=TRUE,all.na=TRUE))
print(b7 <- as.data.frame(a2,band=TRUE,all.na=TRUE,id=TRUE))
```

---

as.integer *Transform values to type integer*

Description

`as.integer` for object of class `ursaRaster` truncates decimal part of image values and then converts to type `integer`.

Usage

```
## S3 method for class 'ursaRaster'
as.integer(x, ...)
```

Arguments

`x`	`ursaRaster` object
`...`	Other arguments which passed to function `as.integer` of package **base**.

Value

Object of class ursaRaster where storage.mode of values is integer.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
a <- pixelsize()
a <- a-min(a)+0.5
str(ursa_value(a))
print(storage.mode(a$value))
b <- as.integer(a)
str(ursa_value(b))
print(storage.mode(b$value))
```

---

as.matrix *Convert raster image to a matrix*

Description

as.matrix(coords=TRUE) prepares a list from the first band of ursaRaster, which is suitable as input parameter for functions image, contour and filled.contour.

Usage

```
## S3 method for class 'ursaRaster'
as.matrix(x, ...)
## S3 method for class 'ursaRaster'
x[[i]]
```

Arguments

x	Object of class ursaRaster
...	Set of arguments, which are recognized via their names (using regular expressions) and classes.
	(coord(s)*|crd|^$) Logical If TRUE then list is created with x, y, z components, where component $z contains matrix, components $x and $y are coordinates for elements if matrix.
i	Positive integer or character of lentg. If integer, then band index. If character, then band name. If missing, then first band (value 1L) is used.

Details

Item `colortable` is mainly for internal usage, e. g., for mapping. Item `proj` is useful for convertion back to `ursaRaster` object by calling `as.ursa` function.

Extract operator `x[[i]]` is a wrapper for `as.matrix(x[i],coords=TRUE)`

Value

Depending of argument `coords`.

If `coords=FALSE`, then it is a two-dimensional matrix `c(samples*lines, bands)`, unclassed from `ursaValue` class.

If `coords=TRUE`, then it is a list:

`x`	Numeric. Midpoints of cells on horizontal axis
`y`	Numeric. Midpoints of cells on vertical axis
`z`	Numeric. Matrix of values
`attr(*, "proj")`	PROJ.4 string for grid, defined by `x` and `y`
`attr(*, "colortable")`	Optional. Object of class `ursaColorTable`. Missing if raster has no color table.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=3,min=0,max=100)
a <- a[a>=20 & a<=80]
ignorevalue(a) <- 121
str(ursa_value(a[2]))
str(as.matrix(a[2]))
b1 <- a[[2]]
str(b1)
image(b1,asp=1)
b2 <- as.matrix(a[2:3],coords=TRUE)
print(c('theSame?'=identical(b1,b2)))
a2 <- as.ursa(b2)
res <- c(src=a[2],exported_then_imported=a2,diff=a[2]-a2)
print(res)
```

`as.Raster` *Coercion to package 'raster' objects*

Description

`as.Raster` converts singe-band `ursaRaster` object to *raster*, multi-band `ursaRaster` object to *brick* and list of `ursaRaster` objects to *stack*. S4 classes "raster", "brick", and "stack" are defined in package **raster**.

Usage

```
as.Raster(obj)

## S3 method for class 'ursaRaster'
as.Raster(obj)

## S3 method for class 'list'
as.Raster(obj)

## S3 method for class 'ursaStack'
as.Raster(obj)

## S3 method for class 'NULL'
as.Raster(obj)
```

Arguments

`obj`	Object of class `ursaRaster` or list of `ursaRaster` objects

Details

Package **raster** is required for conversions.

The uppercase `as.Raster` is important, because `as.raster` is used in internal functions for coercion to object of class `raster`.

Single-banded `ursaRaster` object (with or without colortable) is coerced to `RasterLayer`. Colortables are kept.
Multi-banded `ursaRaster` object is coerced to `RasterBrick`. Colortables are destroyed.
Multi-layered object (list of `ursaRaster` objects) is coerced to `RasterStack`. Colortables are destroyed.

Value

Either `RasterLayer`, `RasterBrick`, or `RasterStack` object.

If package **raster** is not installed then return value is `NULL`

Note

Package **raster** is marked as "Suggested".

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
 ## test is skipped: raster's loading time is close to CRAN allowable test time
session_grid(NULL)
if (requireNamespace("raster")) {
   usedCRS <- ursa:::.crsForceProj4()
   ursa:::.crsForceProj4(TRUE) ## required for CRS comparison
   session_grid(regrid(mul=1/4))
   msk <- ursa_dummy(1,min=0,max=100)>40
   a1 <- ursa_dummy(1,min=200,max=500)[msk]
   a2 <- colorize(a1,ramp=FALSE,interval=FALSE,lazyload=FALSE)
   a3 <- as.integer(ursa_dummy(3,min=0,max=255.99))
   a4 <- ursa_stack(a3[msk])
   if (isLayer <- TRUE) {
      print(a1)
      r1 <- as.Raster(a1)
      message(as.character(class(r1)))
      print(r1)
      print(raster::spplot(r1))
      b1 <- as.ursa(r1)
      print(c(exported=a1,imported=b1,failed=b1-a1))
      print(c(theSameValue=identical(ursa_value(a1),ursa_value(b1))
             ,theSameGrid=identical(ursa_grid(a1),ursa_grid(b1))))
   }
   if (isLayerColortable <- TRUE) {
      r2 <- as.Raster(a2)
      message(as.character(class(r2)))
      print(r2)
      print(raster::spplot(r2))
      b2 <- as.ursa(r2)
      print(c(theSameValue=identical(ursa_value(a2),ursa_value(b2))
             ,theSameGrid=identical(ursa_grid(a2),ursa_grid(b2))))
   }
   if (isBrickOrRGB <- TRUE) {
      r3 <- as.Raster(a3)
      message(as.character(class(r3)))
      print(r3)
      print(raster::spplot(r3))
      raster::plotRGB(r3)
      b3 <- as.ursa(r3)
      print(c(theSameValue=identical(ursa_value(a3),ursa_value(b3))
             ,theSameGrid=identical(ursa_grid(a3),ursa_grid(b3))))
   }
   if (isStack <- TRUE) {
      r4 <- as.Raster(a4)
```

```
    message(as.character(class(r4)))
    print(r4)
    print(raster::spplot(r4))
    b4 <- as.ursa(r4)
    print(c(theSameValue=identical(ursa_value(a4),ursa_value(b4))
           ,theSameGrid=identical(ursa_grid(a4),ursa_grid(b4))))
  }
  ursa:::.crsForceProj4(usedCRS)
}
```

`as.raster` *Export raster object to a colored representation.*

Description

`as.raster` transforms object of class `ursaRaster` to the object of class `raster` (package **grDevices**)

Usage

```
## S3 method for class 'ursaRaster'
as.raster(x, ...)
```

Arguments

`x`	`ursaRaster` object
`...`	Set of arguments, which are recognized via their names (using regular expressions) and classes:
	`max` number giving the maximum of the color values range. Passed to function `as.raster` for S3 class 'array'. Default is 255.

Value

A `raster` object. It is a matrix. The values of matrix are colors.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

`as.array`

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/2))
a <- ursa_dummy(4,min=0,max=255)
a[a<70] <- NA
compose_open(layout=c(1,4),legend=NULL)
for (i in seq(4)) {
   panel_new()
   panel_plot(as.raster(a[seq(i)]),interpolate=FALSE)
   panel_annotation(paste("Number of channels:",i))
}
compose_close()

op <- par(mfrow=c(2,2),mar=rep(0.5,4))
plot(as.raster(a[1:1]),interpolate=FALSE)
plot(as.raster(a[1:2]),interpolate=FALSE)
plot(as.raster(a[1:3]),interpolate=FALSE)
plot(as.raster(a[1:4]),interpolate=FALSE)
par(op)
```

---

as.table *Frequency of unique values*

Description

`as.table` is an implementation of function `base::table` for values of raster image.

Usage

```
## S3 method for class 'ursaRaster'
as.table(x, ...)

ursa_table(x, ...)
```

Arguments

`x`	`ursaRaster` object.
`...`	Other arguments which passed to function `table` of package **base**.

Details

If `ursaRaster` has a `colortable`, then values are replaced by names of categories.

`ursa_table` is synonym to method `as.table` for class `` `ursaRaster` ``.

Value

Object of class `table`.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a <- colorize(pixelsize(),nbreak=4)
t1 <- as.table(a)
print(t1)
str(t1)
ursa_colortable(a) <- NULL
t2 <- as.table(a)
print(t2)
```

`as.ursa` *Create raster image from R objects or GDAL raster files.*

Description

`as.ursa` converts R **base** objects `matrix`, `array`, `numeric`, `data.frame` `list`, **sp** objects `SpatialGridDataFrame`, `SpatialPixelsDataFrame` and `SpatialPointsDataFrame`, **raster** objects `raster`, `stack` and `brick`, and GDAL raster files (using functions from **rgdal** package) to `ursaRaster` object.

Usage

```
as.ursa(obj, ...)
as_ursa(obj, ...)
```

Arguments

`obj`	R object for coercion
`...`	Depending on class of `obj`, arguments are passed to repsective functions.

Details

`as_ursa` is a synonym to `as.ursa`.

This is a high-level function to create `ursaRaster` objects. The follwed classes of R objects are implemented:

'Data Class'	'Appropriate method'
`array`	`ursa_new`
`matrix`	`ursa_new`
`numeric`	`ursa_new`
`data.frame`	`allocate`
`SpatialPointsDataFrame` (**sp**)	`allocate`
`SpatialPixelsDataFrame` (**sp**)	`allocate`
`SpatialGridDataFrame` (**sp**)	`ursa_new`

list of ursaRaster objects	unlist
list returned by sf::gdal_read	ursa_new
list *(general)*	Items $x and $y are required, If lengths of $x and $y are equal to dim of data, then
ggmap (**ggmap**)	ursa_new.
raster (**raster**)	ursa_new.
brick (**raster**)	ursa_new.
stack (**raster**)	ursa_new.
bitmap (**magick**)	ursa_new.
character (GDAL supported file name)	read_gdal.

Generally, allocate is used for objects with non-regular grid, and ursa_new is used for regular grids. The raster grid is defined from object properties or from sessional grid.

Color tables are supported for GDAL file names and **raster** objects (raster, brick, stack).

For ENVI *.hdr Labelled Raster Files there are alternatives:

1. Read object with GDAL (read_gdal);
2. Read object without GDAL (read_envi).

Value

Object of class ursaRaster

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a1 <- as.ursa(volcano)
print(a1)
display(a1)

session_grid(NULL)
b <- ursa_dummy(mul=1/16,bandname=format(Sys.Date()+seq(3)-1,"%A"))
print(b)

c1 <- b[[1]] ## equal to 'c1 <- as.matrix(b[1],coords=TRUE)'
str(c1)
b1a <- as.ursa(c1)
print(c(original=b[1],imported=b1a))
print(c(projection.b1a=ursa_proj(b1a)))
session_grid(NULL)
b1b <- as.ursa(c1$z)
print(b1b)
print(c(projection.b1b=ursa_proj(b1b)))

c2 <- as.data.frame(b)
str(c2)
session_grid(NULL)
```

```
b2a <- as.ursa(c2)
print(b2a)

session_grid(NULL)
attr(c2,"crs") <- NULL
b2b <- as.ursa(c2)
print(b2b)
print(ursa_grid(b2b))

c3 <- unclass(as.matrix(b,coords=TRUE))
str(c3)
session_grid(b)
b3a <- as.ursa(c3)
print(b3a)
print(ursa_grid(b3a))
session_grid(NULL)
b3b <- as.ursa(c3)
print(b3b)
print(ursa_grid(b3b))

c4 <- as.array(b)
str(c4)
session_grid(b)
b4a <- as.ursa(c4)
print(b4a)
print(ursa_grid(b4a))
session_grid(NULL)
b4b <- as.ursa(c4)
print(b4b)
print(ursa_grid(b4b))

n <- 20
c5 <- data.frame(y=runif(n,min=1000000,max=5000000)
                ,x=runif(n,min=-3000000,max=1000000)
                ,value=runif(n,min=0,max=10))
print(head(c5))
session_grid(b)
b5a <- as.ursa(c5)
print(b5a)
 ## to avoid over-timing during tests -- begin
   display(b5a)
 ## to avoid over-timing during tests -- end
session_grid(NULL)
b5b <- as.ursa(c5)
print(b5b)
 ## to avoid over-timing during tests -- begin
   display(b5b)
 ## to avoid over-timing during tests -- end

# b6 <- as.ursa(system.file("pictures/erdas_spnad83.tif",package="rgdal"))
b6 <- as.ursa(system.file("tif/geomatrix.tif",package="sf"))
print(b6)
display(b6,pal=c("black","white"),coast=FALSE,col="orange")
```

```
 ## package 'raster' is required -- begin
if (requireNamespace("raster")) {
   r <- raster::brick(system.file("external/rlogo.gri",package="raster"))
   print(r)
   b7 <- as.ursa(r)
   ursa_proj(b7) <- ""
   print(b7)
   display_rgb(b7)
}
 ## package 'raster' is required -- end
```

---

as_stars *Raster coercion to* ‘stars‘

Description

Coercion from raster ursaRaster object to raster stars object defined in package **stars**.

Usage

```
as_stars(obj)
```

Arguments

obj	Object of class ursaRaster.

Details

Simple coercion to stars object of package **stars**. Currently, color tables and attribution tables are not supported.

Value

Object of class stars for argument of class ursaRaster. Otherwise, NULL.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy(3)
x <- as_stars(a)
class(x)
if (requireNamespace("stars")) {
   print(x)
   b <- as_ursa(x)
   print(a)
```

```
   print(b)
}
```

---

bandname *Band names for raster image.*

Description

bandname (names) returns names of bands for object of class ursaRaster or existing ENVI labelled *.hdr file. bandname<- (names<-) sets names of bands for object of class ursaRaster.

Usage

```
bandname(x)
bandname(x) <- value

## S3 method for class 'ursaRaster'
names(x)

## S3 replacement method for class 'ursaRaster'
names(x) <- value
```

Arguments

x	Object of class ursaRaster. In the bandname function it is allowed to specify character 'ENVI labelled *.hdr' file name.
value	Character of length the same length of number of bands of x

Details

names is a synonym for bandname. names<- is a synonym for bandname<-

Value

For bandname and names, character vector.

For bandname<- and names<-, updated object of class ursaRaster.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

nband

Examples

```
session_grid(NULL)
a1 <- pixelsize()
a2 <- c("Band 1"=a1,Band2=a1/2,sqrt=sqrt(a1),NA)
print(a2)
print(bandname(a2))
bandname(a2)[1:2] <- c("Original","Half")
print(a2)
print(bandname(a2))
```

---

band_group *Extract certain statistics of each band.*

Description

Function from this band.* list returns required statistics for each band.

Usage

```
band_mean(obj)
band_sd(obj)
band_sum(obj)
band_min(obj)
band_max(obj)
band_n(obj)
band_nNA(obj)
band_quantile(obj, ...)
```

Arguments

obj	Object of class ursaRaster.
...	Arguments, which are passed to generic quantile function, e.g. probs, type.

Details

- band_mean returns mean value.
- band_sd returns value of standard deviation with n-1 denominator.
- band_sum returns sum of values.
- band_min returns minimal value.
- band_max returns maximal value.
- band_n returns number of non-NA pixels.
- band_nNA returns number of NA pixels.
- band_quantile returns matrix of quantiles.

Value

Named vector of numerical or integer values. Band names are used for naming.

Note

Currently, implementation is not optimal, because firstly bundle of statistics is computed using band_stat function, and then required statistics is extracted.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

band_stat

Examples

```
session_grid(NULL)
a <- ursa_dummy()
print(a)
print(a<80)
print(class(a))
a[a<80]
a[a<80] <- NA
b1 <- band_stat(a)
print(b1)
b2.n <- band_n(a)
str(b2.n)
b2.mean <- band_mean(a)
print(b1$mean)
print(b2.mean)
print(b1$mean-b2.mean)
print(band_quantile(a))
```

---

band_stat *Computes statistics for each band of raster.*

Description

For each band of ursaRaster object, band_stat returns certain statistics (mean, sd, sum, min, max, number of non-NA pixels, number of NA pixels). Regarding to each band, it is *global* operations of map algebra.

Usage

```
band_stat(x, grid = FALSE, raw = FALSE)
```

Arguments

x	Object of class ursaRaster.
grid	Logical. If TRUE then metadata are returned instead of statistics. Default is FALSE
raw	Logical. For the case of raster values are categories, if raw=TRUE, then function returns statistics of categories; if raw=FALSE and names of categories can be transformed to numerical values, then function returns statistics for decategorized values. Default is FALSE.

Details

If raster values are not in memory or grid=TRUE then ursa_info is returned.

Generic function print for object of class ursaRaster uses returned value of band_stat function with formatted columns.

Statistics is computed for omitted NA values.

Value

data.frame. Row names are indices of bands. Column names are:

name	Band name.
mean	Mean value.
sd	Value of standard deviation with n-1 denomination.
sum	Sum of values.
min	Minimal value.
min	Maximal value.
n	Number of non-NA pixels.
nNA	Number of NA pixels.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

Columns extraction from returned data frame is in the group of band.* functions.

Examples

```
session_grid(NULL)
s <- substr(as.character(sessionInfo()),1,48)
a <- reclass(ursa_dummy(mul=1/2,bandname=s),ramp=FALSE)
band_stat(a,grid=TRUE)
b2 <- band_stat(a)
b3 <- band_stat(a,raw=TRUE)
str(b2)
str(b3)
```

```
print(b2)
print(a) ## 'print.ursaRaster' uses 'band_stat'
print(a,raw=TRUE)
```

---

blank *Does any band contain no information?*

Description

Set of functions for checking is any or all bands have no data, and for retrieving indices for non-data bands.

Usage

```
band_blank(obj, ref = c("any", "0", "NA"), verbose = FALSE)
ursa_blank(obj, ref)
```

Arguments

obj	Object of class ursaRaster
ref	Character. Definition criteria, what is blank mean. If value "0", then blank is detected, if all values are 0. If value "NA", then blank is detected, if all values are NA. Default value is "NA": both NA and 0 are flags of blank. Non-character values are coerced to character.
verbose	Logical. Value TRUE provides progress bar. Default is FALSE.

Details

It is defined locally that if all values of band are NA or 0 (see description to argument ref), then such band is blank. The fact is ursa_new create new object in memory with default values NA, but create_envi writes zeros to disk quick. It is decided to consider both these cases as blank. Function band_blank checks blanks for each band of image. If all bands are blank then function ursa_blank returns TRUE.

Value

Function ursa_blank returns logical value of length 1.

Function band_blank returns logical value of length nband(obj).

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

is.na returns object of class ursaRaster; it is mask of cells, which have NA value.

Examples

```
session_grid(NULL)
a <- ursa_new(bandname=c("first","second","third","fourth"))
ursa_value(a,"first") <- 0 ## 'a[1] <- 1' works, but it is slow
print(ursa_blank(a))
a[3] <- pixelsize()
a[4] <- a[3]>625
print(a)
print(band_blank(a))
print(which(band_blank(a)))
print(ursa_blank(a))
```

---

c *Combine bands into raster brick.*

Description

This function is an instrument for appending bands or for reorganizing bands.

Usage

```
## S3 method for class 'ursaRaster'
c(...)
```

Arguments

`...`	Objects of class `ursaRaster` or coerced to class `ursaRaster`. First argument should be the object of class `ursaRaster`. The objects in the sequence can be named.

Details

You may use this function to assign new bandname for single-band raster: `objDst <- c('Relative density'=objSrc)`

Use also 'Extract' operator `[ ]` to reorganize band sequence.

The returned object can be interpreted as a ***brick*** in the notation of package **raster**. To produce ***stack*** just call `list` or `ursa_stack`.

Value

`ursaRaster` object.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

ursa_brick converts list of ursaRaster objects (***stack***) to a singe multiband ursaRaster object (***brick***).

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/16))
a1 <- ursa_dummy(nband=2)
names(a1) <-  weekdays(Sys.Date()+seq(length(a1))-1)
a2 <- ursa_dummy(nband=2)
names(a2) <- names(a1)
print(a1)
print(a2)
a3 <- a1[1]
print(names(a3))
a4 <- c(today=a3)
print(names(a4))
print(b1 <- c(a1,a2))
print(b2 <- c(a1=a1))
print(b3 <- c(a1=a1,a2=a2))
print(b5 <- c(a1=a1,a2=a2[1]))
print(b4 <- c(a1,'(tomorrow)'=a1[2])) ## raster append
print(b6 <- c(a1,50))
```

---

chunk *Get indices for partial image reading/writing*

Description

In the case of 'Cannot allocate vector of size ...' error message chunk_band returns list of bands indices, which are suitable for allocation in memory at once, chunk_line returns list of lines (rows) indices, which are suitable for allocation in memory at once. chunk_expand is used to expand lines indices and can by applied in focal functions.

Usage

```
chunk_band(obj, mem = 100, mul = 1)
chunk_line(obj, mem = 100, mul = 1)
chunk_expand(ind, size = 3)
```

Arguments

obj	Object of class ursaRaster
mem	Numeric. Memory size in GB, which is suitable for allocation.
mul	Numeric. Expansion or reduction factor (multiplier) of default value of memory allocation.
ind	Integer. Line indices.
size	Integer. Size of focal window.

Value

chunk_band returns list with sequences of bands

chunk_line returns list with sequences of lines

chunk_expand returns list:

src	expanded set if line indices
dst	matching of source indices in the expanded set

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
## 1. Prepare data
session_grid(NULL)
fname <- ursa:::.maketmp(2)
a <- create_envi(fname[1],nband=3,ignorevalue=-99)
for (i in seq(nband(a)))
  a[i] <- pixelsize()^(1/i)
close(a)
rm(a)

## 2. Read
a <- open_envi(fname[1])
chB <- chunk_band(a,2)
str(chB)
for (i in chB)
   print(a[i])
chL <- chunk_line(a,2.5)
str(chL)
for (j in chL)
   print(a[,j])

## 3. Filtering with partial reading
b <- create_envi(a,fname[2])
fsize <- 15
for (j in chL) {
   k <- chunk_expand(j,fsize)
   b[,j] <- focal_mean(a[,k$src],size=fsize)[,k$dst]
}
d1 <- b[]

##  4. Filtering in memory
d2 <- focal_mean(a[],size=fsize)
close(a,b)
envi_remove(fname)
print(d1-d2)
print(round(d1-d2,4))
```

close *Close connections for files with data*

Description

close() for ursaRaster object closes connection for opened file using inheritted function base::close. Function close_envi() closes opened connection for ENVI binary file.

Usage

```
## S3 method for class 'ursaRaster'
close(...)

close_envi(...)
```

Arguments

...	Object or sequence of objects of class ursaRaster.

Value

NULL

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

close of **base** package

Examples

```
session_grid(NULL)
a <- create_envi()
fname <- a$con$fname
message(paste("Created file",dQuote(basename(fname)),"will be deleted."))
print(dir(pattern=basename(envi_list(fname))))
close(a)
invisible(envi_remove(fname))
```

codec *Reduce and restore dimenstions for sparse data matrix*

Description

`compress` reduces dimension of source image matrix and assigns indices. `decompress` uses indices for expansion of reduced image matrix.

Usage

```
decompress(obj)
compress(obj)
```

Arguments

`obj`	Object of class `ursaRaster`

Details

After masking, vectorization of lines, points and small polygons image matrix is often sparse. Compressing (`compress`) is an option to reduce object size in memory. Decompressing (`decompress`) restore original data matrix.

Value

Object of class `ursaRaster`

Note

Currently, usage of compressed image matrix is limited. Spatial filtering (e.g. `focal_mean`) does not operate with compressed data.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
b <- as.data.frame(pixelsize())
b <- subset(b,x>1000000 & x<2000000 & y>3000000 & y<4000000)
a1 <- as.ursa(b)
print(a1)
print(object.size(a1))
a2 <- compress(a1)
print(a2)
print(object.size(a2))
a3 <- decompress(a2)
print(a3)
```

```
print(object.size(a3))
print(identical(a1,a3))
```

`colorize` *Create color table*

Description

`colorize` assigns color table to raster image.

Usage

```
colorize(obj, value = NULL, breakvalue = NULL, name = NULL, pal = NULL, inv = NA,
         stretch = c("default", "linear", "equal", "mean", "positive",
                     "negative", "zero", "diff", "category", "julian",
                     "date", "time", "slope", "conc", "sd", "significance",
                     "bathy", "grayscale", "greyscale"),
       minvalue = NA, maxvalue = NA, byvalue = NA, ltail = NA, rtail = NA, tail = NA,
       ncolor = NA, nbreak = NA, interval = NA_integer_, ramp = FALSE, byte = FALSE,
          lazyload = TRUE, reset = FALSE, origin = "1970-01-01" ,format = "",
          alpha = "", colortable = NULL, verbose = FALSE, ...)

palettize(...) ## wrapper for non-spatial vectors
```

Arguments

`obj`	`ursaRaster` object or one-dimension numeric or character vector.
`value`	Numeric. Values to be assigned to categories.
`breakvalue`	Numeric. Values to be assigned to intervals.
`name`	Character. Names of categories.
`pal`	Function or character. If function then value should corresponded to function, which creates a vector of colors. If character then values should correponded to R color names or hexadecimal string of the form "#RRGGBB" or "#RRGGBBAA".
`inv`	Logical. Invert sequence of colors.
`stretch`	Character. Either kind of value transformation (`"linear"`, `"equal"`) or predefined options with palette specification (`"positive"`, `"data"`, `"significance"`, etc)
`minvalue`	Numeric. Lower range limit.
`maxvalue`	Numeric. Upper range limit.
`byvalue`	Numeric. Increment of the sequence from `minvalue` to `maxvalue`.
`ltail`	Numeric. Partition of omitted values at left tail.
`rtail`	Numeric. Partition of omitted values at right tail.

tail	Numeric. Partition of omitted values at both tail. If length of tail is 2 then left and right tails may differ.
ncolor	Numeric or interer. Number of desired colors (or categories).
nbreak	Numeric or interer. Number of desired separators between colors.
interval	Integer or logical. Logical is coerced to integer. How to underwrite categories? Value 0L means that for numeric data each color gradation corresponds to intervals but named as a single value (e.g., middle between low and high values). Value 1L means that values correspond to separators of color gradation. Value 2L is experimental for scales with zero. Default is NA: interval=0L for ramp=TRUE and interval=1L for ramp=FALSE.
ramp	Logical. Is color ramp required?
byte	Logical. Forcing to produce color table for storage in byte format (not more than 255 colors). Default is FALSE.
lazyload	Logical. If FALSE then raster is reclassified to categories. If TRUE then color table is created without any change to source raster and raster value just postponed for change. Default is TRUE.
reset	Logical. If TRUE and source raster has color table, then this color table is destroyed, and new one is created. Default is FALSE.
origin	Character. Origin for stretch="date" (passed to function as.Date) and stretch="time" (passed to function as.POSIXct). See desription of orogin in respective functions. Default is "1970-01-01".
format	Character. Format date/time objects for arguments stretch with values "date", "time", or "julian". Default is "" (character of length 0).
alpha	Character or numeric. The characteristics of transparency. If character, then hexadecimal values between "00" and "FF" are allowed, and then coerced to numeric value between 0 and 255. If numeric, and 0 <= alpha <= 1, then alpha is multiplied to 255. alpha=0 means full transparency, alpha=255 means full opacity. Default is ""; if palette has no alpha channel, then alpha is assign to "FF".
colortable	Object of class ursaColorTable or object of class ursaRaster with color table. Reference color table. Is specified, then all other arguments are ignored, expexted lazyload. Default is NULL (unspecified).
verbose	Logical. Some output in console. Primarily for debug purposes.
...	For colorize(): If pal is a function, and argument names are in the format "pal.*" then prefix "pal." is omitted, and the rest part is used for argument names, which are passed to pal function. For palettize(): Arguments, which are passed to colorize().

Details

palettize is a wrapper ursa_colortable(colorize(...)) to return color table for one-dimensional numeric or character vector.

colortable is designed to prepare pretty thematic maps.

Color rampimg (ramp=TRUE) is not quick in computatons and has no effective labelling. It is intoduced to visualize non-thematic maps, and it is assumed that labeling can be omitted for such maps.

The labelling implementation is based on some improvements of pretty function. The notation of intervals is mixed by brackets and comparative symbols, for example: "<=1.5","(1.5,2.5]","(2.5,3.5]",">3.5"

Reserved values for interval:

- 0L or FALSE - no interlavs. Values are interpreted as category, even if they are in non-nominal scale
- 1L or TRUE - each category corresponds to interval. The low limit of lowest category is -Inf. The high limit of highest category is +Inf
- 2L - different implementation of interval=1. In some cases may relult more pretty labeling.
  If breaks is numerical vector and colors has zero length, then it is assumed interal scaling, and interval=1L is assigned to unspecified interval
  Finite values of extreme intervals are neccessary sometimes, however this option is not implemented currently

Keywords for stretch to create pre-defined color tables:

- "positive" - lower limit is 0. Palette is "Oranges"
- "negative" - higher limit is 0. Palette is "Purples"
- "grayscale", "greyscale" - palette is "Greys". Usually used for raw satellite images.
- "mean" - designed for common thematic maps and for averaged map across set of maps. Palette is "Spectral"
- "sd" - designed for spatial mapping of standard deviation across set of maps. Palette is "YlGnBu"
- "diff" - diverge palette "RdBu". Absolute values of lower and upper limits are equal, zero is in the middle of palette. Designed for anomaly maps.
- "slope" - is similar to diff but without extreme colors, which are reserved for contouring of statistically significant areas.
- "significance" - desiged to illustrate statistically significant areas of slope. The realisation is colortable(obj, value=c(-0.999, -0.99, -0.95, -0.9, -0.5, +0.5, +0.9, +0.95, +0.99, +0.999), interval=1L, palname="RdBu")
- "category" - Values are interpreted in nominal scale. Palette is based on random colors from "Pairs" palette.
- "conc" - designed for visualization of sea ice concentration data, which have lower limit 0 and higher limit 100. Palette is "Blues"
- "bathy" - designed for ocean depth (bathymetry) maps. Internally colorize(obj, stretch="equal",interval=1L, palname="Blues", inv=TRUE) is used to detect the crossing from shelf waters to deep water basin. Better practice is to do second step with manual specification of value argument.
- "internal" - continuous colors, designed for conversion to greyscale with keeping of intensities.
- "default" - allowing to detect stretch by intuition, without any strong mathematical criteria

It is allowed manual correction of labels using followed code example: names(ursa_colortable(x)) <- c("a<=0","0<a<=1","a>1")

Value

Object of class `ursaRaster` with named character vector of item `$colortable`

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

ursa_colortable, ursa_colortable<-

Examples

```
session_grid(NULL)
a <- pixelsize()-350
print(a)
b1 <- colorize(a,ramp=FALSE)
print(ursa_colortable(b1))
b2 <- colorize(a,interval=1,stretch="positive",ramp=FALSE)
print(ursa_colortable(b2))
b3 <- colorize(a,interval=2,stretch="positive",ramp=FALSE)
print(ursa_colortable(b3))
b4 <- colorize(a,value=c(150,250),interval=1)
print(ursa_colortable(b4))
names(ursa_colortable(b4)) <- c("x<=150","150<x<=250","x>250")
print(ursa_colortable(b4))
display(b4)
```

---

colortable *Color Tables of raster images.*

Description

Manipulation with color tables of raster images.

Usage

```
## S3 method for class 'ursaColorTable'
print(x, ...)

## S3 method for class 'ursaColorTable'
x[i]


ursa_colortable(x)

ursa_colortable(x) <- value
```

```
ursa_colorindex(ct)

ursa_color(ct, ...)

## S3 method for class 'ursaColorTable'
names(x)

## S3 replacement method for class 'ursaColorTable'
names(x) <- value
```

Arguments

x	ursaRaster object. Extended for numeric (integer or real) of character vector.
ct	ursaColorTable object with or without indexing.
value	Named character vector. In Replacement functions: For ursa_colortable(): values are colors in "#RRGGBB" notation or R color names (colors). names(value) are names of categories. For names(): values are names of categories. If length of names is n-1, where n is length of colors, then intervaling is assumed, and value are assign to interval breaks.
i	Integer vector. Indices specifying elements to extract part (subset) of color table.
...	In print(), passing to generic print. Currently not used. In ursa_colortable(), passing to generic print. Currently not used. In ursa_color(), passing to colorize.

Details

The example of the class structure

```
Class 'ursaColorTable'  Named chr [1:4] "#313695" "#BCE1EE" "#FDBE70" "#A50026"
  ..- attr(*, "names")= chr [1:4] "<= 450" "(450;550]" "(550;650]" "> 650"
```

It is recommended to use ursa_colortable and ursa_colortable<- instead of colortable and colortable<-. ursa_colortable and colortable are synonyms. ursa_colortable<- and colortable<- are synonyms too. Package **raster** contains colortable and colortable<- functions. colortable and colortable<- will be remove from this package if the case of frequent joint use of both packages.

If color tables describe continuous and non-intersecting intervals, then print gives additional line of extracted breaks.

Value

ursa_colortable returns value of $colortable element if ursaRaster object.

ursa_colortable<- returns ursaRaster object with modified $colortable element.

Class of $colortable element is "ursaColorTable". This is named character vector, where names are categories, and values are "#RRGGBB" or R color names.

Extract function `[]` for `ursaColorTable` object returns object of class `ursaColorTable`.

Extract function `names` for `ursaColorTable` object returns character vector (names of categories).

Replace function `names<-` for `ursaColorTable` object returns `ursaColorTable` with changed names of categories.

`ursa_colorindex` returns index (if presents) for `ursaColorTable` object.

`ursa_color` returns character vector of colors in hex format.

Color tables are written to ENVI header file.

Warning

If colors are specified as R color names, then slow down may appear.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

colorize

Examples

```
session_grid(NULL)
print(methods(class="ursaColorTable"))

a <- pixelsize()
print(a)
b1 <- colorize(a,value=c(400,500,600,700),interval=FALSE)
b2 <- colorize(a,value=c(450,550,650)    ,interval=TRUE)
display(list(b1,b2))
print(is.ursa(a,"colortable"))
print(is.ursa(b1,"colortable"))
print(is.ursa(b2,"colortable"))
print(ursa_colortable(a))
print(ursa_colortable(b1))
print(ursa_colortable(b2))
ursa_colortable(b2) <- c("Low"="darkolivegreen1"
                        ,"Moderate"="darkolivegreen2"
                        ,"High"="darkolivegreen3"
                        ,"undefined"="darkolivegreen4")
print(ursa_colortable(b2))
names(ursa_colortable(b2))[4] <- "Polar"
print(ursa_colortable(b2))
display(b2)

lab <- sample(c("A","B","C"),9,replace=TRUE)
lab
ct <- ursa_color(lab)
names(ct) <- lab
ct
```

commonGeneric *Some generic functions for* ursaRaster *class.*

Description

Set of generic functions, implemented for objects of ursaRaster class.

Usage

```
## S3 method for class 'ursaRaster'
duplicated(x, incomparables = FALSE, MARGIN = 2, fromLast = FALSE, ...)

## S3 method for class 'ursaRaster'
diff(x, lag = 1, differences = 1, ...)
```

Arguments

x	Object of ursaRaster class
incomparables	Passed to S3 method duplicated for class matrix.
MARGIN	Overwitten to value 2. Passed to S3 method duplicated for class matrix.
fromLast	Passed to S3 method duplicated for class matrix.
lag	Passed to default S3 method diff.
differences	Passed to default S3 method diff.
...	Other arguments, which are passed to the respective S3 method.

Value

duplicated(): logical of length equal to number of bands.

diff(): ursaRaster object.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

duplicated, diff,

Examples

```
a <- ursa_dummy(5)
a[3] <- a[2]
a
duplicated(a)
diff(a)
```

compose_close *Finish plotting*

Description

Function compose_close does followed tasks: 1) completes all unfinsished actions before shutting down graphical device, 2) cuts extra margins, and 3) opens resulted PNG file in the associated viewer.

Usage

```
compose_close(...)

## non-public
.compose_close(kind = c("crop2", "crop", "nocrop"),
               border = 5, bpp = 0, execute = TRUE, verbose = FALSE)
```

Arguments

...	Set of arguments, which are recognized via their names and classes, and then passed to .compose_close:

Pattern (compose_close)	**Argument** (.compose_close)
(^$|crop|kind)	kind
(border|frame)	border
bpp	bpp
(render|execute|view|open)	execute
verb(ose)*	verbose

kind	Character keyword for cutting of excess white spaces. If kind="nocrop" then there is no cut. If kind="crop" then only outer margins are cutted. If kind="crop2" then all outer margins and inner white spaces (*e.g.*, between color bar panel and text caption) are cutted.
border	Non-negative integer. Number of pixels for margins, which are not cropped. Default is 5L.
bpp	Integer. Bits per pixel for output PNG file. Valid values are 0L, 8L, 24L. If bpp=0L, then 8 bpp is used for "windows" type of PNG device, and 24 bpp is used for "cairo" type of PNG device. The type of device is specified in compose_open function.
execute	Logical. Should created PNG file be opened in the associated external program for viewing graphical files? Default is TRUE.
verbose	Logical. Value TRUE provides some additional information on console. Default is FALSE.

Details

The cut manipulations (`crop="crop"` or `crop="crop2"`) are implemented using `readPNG` and `writePNG` functions of package **png**. These fuctions have limitations in the memory allocation.

Function `compose_close` clears all internal graphical options, specified during `compose_open` executing.

Some parameters are specified in `compose_open`: weather output PNG file will be removed after opening (logical `delafter`), or what is the time of waiting for file opening and next removing (numerical `wait` in seconds).

Value

Function returns `NULL` value.

Warning

Currenty, `execute=TRUE` is implemented for Windows platform only using construction `R CMD open \emph{fileout}`.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=6,min=0,max=255,mul=1/4)

## exam 1
compose_open()
compose_close()

## exam 2
compose_open(a)
compose_close()

## exam 3
compose_open("rgb",fileout="tmp1")
compose_plot(a[1:3])
compose_close(execute=FALSE)
Sys.sleep(1)
a <- dir(pattern="tmp1.png")
print(a)
file.remove(a)
```

compose_design *Organize multi-panel layout with images and color bars.*

Description

compose_design prepares scheme for layout of images and color bars.

Usage

```
compose_design(...)
```

Arguments

...	Set of arguments, which are recognized via their names and classes:
	obj Object of class ursaRaster or list of objects of class ursaRaster or NULL. Default is NULL. Used to detect panel layout and coordinate reference system.
	layout Integer of length 2, integer of length 1, two-dimensional matrix or NA. Layout matrix has dimensionsc(nr, nc), where nr is number of rows, and nc is number of columns. If layout is positive integer of length 1, then sequense of this value unfolds to layout matrix using argument ratio. If layout=NA then layout matrix is recognized internally using number of bands of obj and argument ratio. If layout=NA and obj=NULL then matrix c(1,1) is used.
	byrow Logical. The order of filling of layout matrix. Default is TRUE. If byrow=TRUE then matrix is filled by rows (from top row, consequently from left element to right element, then next row). If byrow=FALSE then matrix is filled by columns.
	skip Positive integer of variable length. Default in NULL (length is zero). Indices of panels in the layout matrix, which are not used.
	legend The descripition of rules how color bars (legends) or panel captions are located in the layout. It is the list of embedded lists of two elements, which describe the color bars position in the layout. of Default is NA, it means using of internal rules. If legend=NULL then no plotting of color bars. If legend is positive integer in the range 1L:4L, then sinlge color bar is used and legend's side is corresponded to margins of R graphic system.
	side Positive integer 1L, 2L, 3L, or 4L. Default is NA. Simplification of color bar position in the case that single color bar is used. The value is corresponded to margins of R graphic system. The synonym of integer value of legend.
	ratio Positive numeric. The desired ratio of layout sides (width per height). If layout=NA then the dimensions of layout matrix are defined internally to get the given ratio of layout's width per height. The default is (16+1)/(9+1) in the assumtion of optimal filling on the usual 16:9 screens.

`fixed` Logical. If `TRUE` then it is assuming that layout will have the same proportions as sessional grid sizes (rows and columns). For this case, argument `ratio` is reassigned as a desired ratio (width per height) for single panel. Default is `FALSE`.

Details

Function `compose_design` extracts and validates required arguments from a list of parameters (three-dots construct) and passes them to internal function `.compose_design`.

Argument `legend` is a `list` or coerced to a `list`. The length of this list is equal to number of color bars; each item describes certain color bar. This desctiption is a list again with two elements, which desribes the position of color bar in relation to main panels of images.

If argument `legend` is in interval `1L:4L` then it is interpreted as argument `side` in functions `axis`, `mtext`. Argument `side` in function `compose_design` plays the same role. It is introduced for consistency with R graphic system.

In the one of example below (See *Examples* section) the layout with dimension of two rows by three columns is considered (`layout=c(2,3)`). The dimension of resulting layout matrix is `c(7,9)`, where 7=**2***2+3, and 9=**3***2+3.

```
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9]
[1,]    0    0    0    0    0    0    0    0    0
[2,]    0    0    0    0    0    0    0    0    0
[3,]    0    0    1    0    2    0    3    0    0
[4,]    0    0    0    0    0    0    0    0    0
[5,]    0    0    4    0    5    0    6    0    0
[6,]    0    0    0    0    0    0    0    0    0
[7,]    0    0    0    0    0    0    0    0    0
```

The complicated color bar structure is specified via R's `list` function:

```
>   leg <- list("7"=list(row=1,col=0),"8"=list(2,"left")
+              ,"9"=list("full","right"),"10"=list("top","full")
+              ,"11"=list(99,1:2),"12"=list("bottom",3))
> str(leg)
 $ 7 :List of 2
  ..$ row: num 1
  ..$ col: num 0
 $ 8 :List of 2
  ..$ : num 2
  ..$ : chr "left"
 $ 9 :List of 2
  ..$ : chr "full"
  ..$ : chr "right"
 $ 10:List of 2
  ..$ : chr "top"
  ..$ : chr "full"
 $ 11:List of 2
  ..$ : num 99
```

```
  ..$ : int [1:2] 1 2
 $ 12:List of 2
  ..$ : chr "bottom"
  ..$ : num 3
```

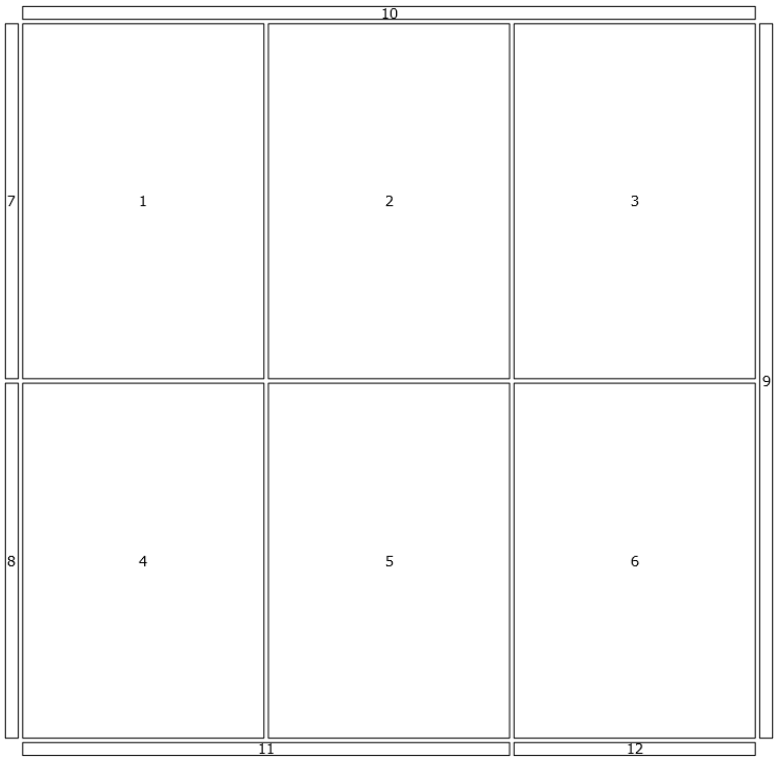
Here, six color bars are specified. It is a list of six lists (sub-lists). First item of sub-list is row number, and the second one is column number. Integers can be replaces by character keywords.

For row-position, `"top"` means `0L` (less than first row), `"bottom"` means large integer value (greater than last row, currently, `99L`), `"first"` means `1L`, `"last"` means number of last row (`2L` in this example), `"full"` means whole range from first to last rows (`1L:2L` in this example). Values `"top"` and `"bottom"` are used for horizontal color bars (last three sub-lists), and the rest for vertical color bars (first three sub-lists).

For column-position, `"left"` means `0L` (less then first column), `"bottom"` means large integer value (greater than last column, currently, `99L`), `"first"` means first column (`1L`), `"last"` means last column (`3L` in this example), `"full"` means whole range from first to last columns ((`1L:3L` in this example)). Values `"left"` and `"right"` are used for vertical color bars, and the rest are for horizontal ones.

The resulting layout is a sparse matrix with zero values for each even row and each column. These zeros plays role of white space between panels in the plotted layout. In our example, values `1L:6L` are corresponded to six map panels, and values `7L:12L` are corresponded to six narrow panels of color bars (legends).

```
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9]
[1,]    0    0   10    0   10    0   10    0    0
[2,]    0    0    0    0    0    0    0    0    0
[3,]    7    0    1    0    2    0    3    0    9
[4,]    0    0    0    0    0    0    0    0    0
[5,]    8    0    4    0    5    0    6    0    9
[6,]    0    0    0    0    0    0    0    0    0
[7,]    0    0   11    0   11    0   12    0    0
```



Value

It is a list of class `ursaLayout`.

`layout`	Integer matrix with dimension `c(2*nr+3, 2*nc+3)`, where `nr` and `nc` are number of rows and colunms of the layout matrix. The layout matrix of image panels is surrounded by colorbar panels. The original layout matrix is expanded by adding zero columns and rows. In the new matrix each even column has zero values, and each even row has zero values.
`image`	Nonnegative integer. Number of panels with images.
`dim`	Nonnegative integer of length two. Number of rows and number of columns for panel layout.
`legend`	Nonnegative integer. Number of panels with color bars (legends).

The returned value is passed to function `compose_open` and further is kept in the `options` until calling of `compose_close`.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
```

```
a <- ursa_dummy(nband=5,min=1,max=200,mul=1/8)
b <- list(colorize(a[1:3],pal.rich=240,pal.rotate=0)
         ,colorize(sqrt(a[4:5]),pal.rich=-15,pal.rotate=0,stretch="equal"))

cl1 <- compose_design(layout=c(2,3),byrow=TRUE,legend=NULL)
print(cl1)
compose_open(cl1)
compose_close()

cl2 <- compose_design(layout=c(2,3),byrow=FALSE,legend="left")
print(cl2$layout)
compose_open(cl2)
compose_close()

cl3 <- compose_design(a,side=2)
print(cl3)
compose_open(cl3)
compose_close()

cl4 <- compose_design(b)
print(cl4)
 ## to avoid over-time during example check -- begin
   compose_open(cl4)
   compose_plot(b,decor=FALSE,las=2)
   compose_close("nocrop")
 ## to avoid over-time during example check -- end

cl5 <- compose_design(b,byrow=FALSE,skip=3
                     ,legend=list(list("full","left"),list(1:2,"right")))
compose_open(cl5)
compose_plot(b,decor=FALSE)
compose_close("nocrop")

leg <- list(list(1,0),list(2,"left")
           ,list("full","right"),list("top","full")
           ,list(99,1:2),list("bottom",3))
str(leg)
cl6 <- compose_design(layout=c(2,3),skip=NA,legend=leg)
print(cl6)
compose_open(cl6,scale=3,pointsize=16)
compose_close("nocrop")

cl7 <- compose_design(layout=matrix(c(1,1,3,2,2,0),nrow=2,byrow=TRUE))
print(cl7)
compose_open(cl7)
compose_close()
```

---

compose_legend *Plot colorbars or marginal texts.*

Description

compose_legend recognizes color tables and characters among arguments and passes them to suitable functions for plotting on margins outside of panel area.

Usage

```
compose_legend(...)
```

Arguments

...	If first argument is a list, then either ursaColorTable or character objects are detected in this list. ursaColorTable can be extracted from ursaRaster (if presents). Other objects are coerced to character. If first argument is ursaColorTable or ursaRaster with color tables, then other arguments are interpreted as color tables. If coercion to color table is impossible, the coersion is to character. legend_colorbar is called for objects of class ursaColorTable. legend_mtext is called for objects of class ursaColorTable. If first argument is a list, then other arguments are passed to respective function calls.

Details

Named list in the first argument is allowed or named vectors are allowed if first argument is not a list. For legend_colorbar name of object can be used as an argument units.

This function is designed to make plot on moderate level of usage with the followed construction:

```
compose_open(...)
compose_panel(...)
compose_legend(...)
compose_close(...)
```

Function compose_panel returns list of color tables of plotted rasters, and followed sequence is available:

```
ct <- compose_panel(a)
compose_legend(ct) # or, if 'a' has color tables, then 'compose_legend(a)'
```

Value

NULL

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

legend_colorbar

legend_mtext

Examples

```
session_grid(NULL)
b <- lapply(as.list(ursa_dummy(2)),colorize)
cd <- compose_design(layout=c(1,2),legend=list(list(1,"left"),list(1,"right")
                                               ,list("top","full"),list("bottom",1)))
for (i in 1:4) {
   compose_open(cd,dev=i==1)
   ct <- compose_panel(b,decor=FALSE)
   if (i==2)
      compose_legend(ct)
   else if (i==3)
      compose_legend(ct[[1]],'Tomorrow'=b[[2]]
                     ,top="This is example of legend composition"
                     ,format(Sys.Date(),"(c) %Y"))
   else if (i==4)
      compose_legend(c(ct,"top","bottom"),units=c("left","right"))
   compose_close()
}
```

`compose_open` *Start displaying*

Description

`compose_open` create plot layout and open PNG graphic device.

Usage

```
compose_open(...)
```

Arguments

`...`	Set of arguments, which are recognized via their names and classes:
	`mosaic` Layout matrix or reference object to produce layout matrix. It is permitted to do not use name for this argument. Multiple types of argument are allowed: 1) object of class `ursaRaster`, 2) `list` of `ursaRaster` objects (raster stack), 3) object of class `ursaLayout` from function `compose_design`, 4) character keyword or 5) missing. Default is `NA`.
	`fileout` Character. Name for created output file. Supported PNG (*.png), JPEG (*.jpg), WEBP (*.webp) and SVG (*.svg) extensions. Missed extension assumes PNG. If absent (`""`) then temporal file is created and removed in `wait` seconds after opening in the associated external viewer. Default is absent (`""`).
	`dpi` Positive integer. Dots (or pixels) per inch (DPI). The nominal resolution of created output (default PNG) file. Default is `96L`. The same as `res` argument in the `png` function.

`pointsize` Positive integer. The pointsize of plotted text as it is applied in the png function. Default is `NA`. If `pointsize=NA` then it is taken value `16L` multiplied to relative DPI (`dpi/96`). In the case of unspecified `scale` and `pointsize` the size of text is defined internally.

`scale` Positive numeric or character. The scale factor applied to dimensions of original raster. Default is `NA`. If `scale` is unspecified (`scale=NA`), then `scale` is defined internally for *intuitively* better fitting in HD, FHD displays (single-panelled layout 900x700). If `scale` is character (e.g., `"8000000"`, `"1:8000000"`) then dimensions of image panels are defined using "one centimeter of map is corresponded to 8000000 centimeres of site" rule.

`width` Positive numeric or character. The desired width of each panel of multipanel layout. If `width` is numeric, then units are pixels. If `width` is character (e.g., `"12.5"`, `"12.5 cm"`, `"12.5cm"`) then units are centimeters in agreement with `dpi` argument. Default is `NA`. If `width` is unspecified (`width=NA`) then value `900` is used for single panelled layout.

`height` Positive numeric or character. The desired height of each panel of multipanel layout. If `height` is numeric, then units are pixels. If `height` is character (e.g., `"9.6"`, `"9.6 cm"`, `"9.6cm"`) then units are centimeters in agreement with `dpi` argument. Default is `NA`. If `height` is unspecified (`height=NA`) then value `700` is used for single panelled layout.

`colorbar` **or** `colorbarwidth` Positive numeric. Scale factor to increase (`colorbar>1`) or decrease (`colorbar<1`) width (the shortest dimension) of color bars (legends). Default value (`NA`) means 2.8% of image panel width.

`indent` **or** `space` **or** `offset`**.** Positive numeric. Scale factor to increase (`space>1`) or decrease (`space<1`) the white space between image panels and between image and color bar panels. Default value (`NA`) means 0.8% of image panel width.

`box` Logical. If `TRUE` then boundary box is plotted around image panels and color bar panels. It is a transparent rectangle with black border. Default is `TRUE`.

`delafter` Logical. If `TRUE` then created PNG file will be deleted after viewing. Default is `FALSE` for specified file names and `TRUE` for unspecified (temporal) file names. It is implemented as file removing after opening in the external PNG viewer.

`wait` Positive numeric. Seconds between PNG file opening in the associated program and file removing. It make sense only if `delafter=TRUE`. Default is `1.0` (one second).

`device` **or** `type` Character keyword, either `"cairo"`, `"windows"` or `"CairoPNG"` for OS Windows, and either `"cairo"`, `"cairo-png"`, `"Xlib"` or `"quartz"` for other OSes. Should be plotting be done using cairographics or Windows GDI? The same as `type` argument in the png function, excepting `"CairoPNG"`, which is handed by **Cairo** package. Default is `"cairo"`.

`antialias` Character keyword, either `"none"` or `"default"`. Defines the effect on fonts. The same as `antialias` argument in the png function. Default is `"default"`.

`font` **or** `family` A length-one character vector. Specifies the font family. The same as `family` argument in the png function. Default is `"sans"` for `device="windows"`

and "Tahoma" for device="cairo".

bg **or** background Character. The background color in PNG file. Passed as argument bg to png function. Default is "white"

retina Positive numeric. Scale coefficent for retina displays. Default is taken from getOption("ursaRetina"); if it missed, then 1.

dev Logical. If TRUE then this **dev**eloper tool shows created layout without any the followed plot functions from this package are ignored. Default is FALSE

verbose Logical. Shows additional output information in console. Default is FALSE.

... Arguments, which can be passed to compose_design function.

Details

Other usage of compose_open(...,dev=TRUE) is

```
compose_open(...,dev=FALSE)
compose_close()
```

The reason to use compose_design function before compose_open is to reduce number of arguments in the case of complicated layout matrix and non-standard settings.

compose_open passes arguments to png function.

If character values are specified for arguments width, height or scale, then layout development is oriented to produce PNG file, which will be used as a paper copy. Character values for width and height are in centimeters. Character value V or 1:V of scale defines scale 1/V.

The Cairo device (device="cairo") is more quick on MS Windows computers. However Windows GDI may produce less depth of colors (even 8 BPP) in the case of no font antialiasing. Usage of Windows GDI (device="windows") is a way to produce illustations for scientific journals with strict requirements of mininal line width, font size, *etc*.

The PNG layout reserves extra margins for captions of color bars. These margins are filled by white spaces. The cropping of layout applies to created PNG file using read-write functions of package **png**. Only white ("white", "#FFFFFF") or transparent ("transparent") colors are regognized as white spaces. Therefore, specification of bg!="white" or bg!="transparent" breaks PNG image cropping.

It is noted that Cyrillics is supported on Windows GDI (device="windows") and is not supported on Cairo (device="cairo") types of PNG device on MS Windows platform.

Argument retina is ignored for leaflet-compatible tiling.

Value

Name of created PNG file.

If dev=TRUE then output on console is layout matrix.

The set of required parameters for plotting are kept until function compose_close call via options.

ursaPngAuto For developers. Indicator of high-level functions for internal use (manual set; value is TRUE). Or, can be missed.

`ursaPngBox` Argument box. If TRUE then box is called for each panel of layout at the end of plotting.

`ursaPngDelafter` Argument delafter. Applied in the function compose_close.

`ursaPngDevice` Argument device. Applied for effective plottting of rasters and checking the ability for final reducing color depth from 24 to 8 bpp.

`ursaPngDpi` Argument dpi. Currently used for verbose only.

`ursaPngFamily` Applied for text plotting in annotations and legends.

`ursaPngFigure` Set 0L. Specifies number of current panel in layout matrix. Used to detect term for applying $ursaPngBox option.

`ursaPngFileout` Name of created PNG file.

`ursaPngLayout` Layout matrix, the object of class ursaLayout.

`ursaPngPaperScale` Numeric. Used for scalebar representation on the paper-based maps. If value 0, then scalebar is display-based. If value is greater 0 then the scale is exact. If value is -1 then the resonable rounding is used for scale displaying.

`ursaPngPlot` The opposite to argument dev. If $ursaPngPlot is FALSE then any plotting functions of this package are ignored.

`ursaPngScale` The actual value of argument scale, specified during function call or stated internally.

`ursaPngShadow` Set "". Used for shadowing of the part of color bars in the case of semi-transparent land or ocean filling mask in the panel_coastline function.

`ursaPngSkipLegend` Integer vector of non-negative length. Defines list of images panels, for which the color bars are not displayed.

`ursaPngWaitBeforeRemove` Argument wait. Applied in the function compose_close for temporal PNG file.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
b <- ursa_dummy(nband=4,min=0,max=50,mul=1/4,elements=16)
p <- list(colorize(b[1:2],pal.rich=240,pal.rotate=0)
         ,colorize(sqrt(b[3:4]),pal.rich=-15,pal.rotate=0,stretch="equal"))
p

## exam #01
compose_open(width=950,dpi=150,pointsize=16,legend=NULL,dev=TRUE)

## exam #02
compose_open(pointsize=8,dpi=150,scale="1:130000000")
compose_plot(colorize(b[1]),scalebar=TRUE,coast=FALSE)
```

```
compose_close()

## exam #03
cl <- compose_design(layout=c(2,4)
                     ,legend=list(list("top","full"),list("bottom",1:3)))
compose_open(cl,dev=TRUE)

## exam #04
cl <- compose_design(p,layout=c(2,3),skip=c(2,4,6))
compose_open(cl,dev=TRUE)

## exam #05
cl <- compose_design(p,side=3)
compose_open(cl,dev=FALSE,bg="transparent")
compose_close()
```

`compose_panel` *Plot raster images and decorations on the multipanel layout.*

Description

`compose_panel` divides the multi-band raster image (*brick*) or layers of raster images (*stack*) on the sequence of single-band images and plots each image on the separate panel of layout. Panel plotting is finalized by adding of decoration (gridlines, coastline, annotation, scalebar).

Usage

```
compose_panel(..., silent = FALSE)
```

Arguments

`...`	Set of arguments, which are passed to `panel_new`, `panel_raster`, `panel_coastline`, `panel_graticule`, `panel_annotation`, `panel_scalebar`.
`silent`	Logical. Value `TRUE` cancels progress bar. Default is `FALSE`.

Details

For each panel of layout the sequence of called functions is permanent:
`panel_new` - - > `panel_raster` - - > `panel_coastline` - - > `panel_graticule` - - > `panel_annotation` - -> `panel_scalebar`.

If this order is undesirable, then call these functions in the required sequence.

Value

`NULL`

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

compose_plot, compose_legend

panel_new, panel_raster, panel_coastline, panel_graticule, panel_annotation, panel_scalebar

Examples

```
session_grid(NULL)
a <- ursa_dummy(6)
b1 <- list(maxi=a[1:4]*1e2,mini=a[5:6]/1e2)
print(b1)
b2 <- lapply(b1,function(x) colorize(x,nbreak=ifelse(global_mean(x)<100,5,NA)))
compose_open(b2,byrow=FALSE
            ,legend=list(list("bottom",1:2),list("bottom",3),list("left")))
ct <- compose_panel(b2,scalebar=2,coastline=3:4,gridline=5:6,gridline.margin=5
                   ,annotation.text=as.character(seq(6)))
compose_legend(ct)
legend_mtext(as.expression(substitute(italic("Colorbars are on the bottom"))))
compose_close()
```

---

compose_plot *Plot layout of images and color bars.*

Description

compose_plot plots images (raster brick or raster stack) and corresponding color bars according to given rectangular layout.

Usage

```
compose_plot(...)
```

Arguments

...	Set of arguments, which are passed to compose_panel and compose_legend

Details

Function merges to functions. The first one plots image layout and returns list of color tables. The second one plots legend (colorbars) based on returned color tables. Simplified description is:

```
ct <- compose_panel(...)
compose_legend(ct,...)
```

These two functions are separated to allow use additional plotting on image panel after primary plot of raster and decorations before panel change or legend plot.

Value

This function returns NULL value.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

compose_panel
compose_legend

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=6,min=0,max=255,mul=1/4)
if (example1 <- TRUE) {
   b1 <- ursa_brick(a)
  # b1 <- colorize(b1,stretch="positive",ramp=FALSE)
   compose_open(b1)
   compose_plot(b1,grid=FALSE,coast=FALSE,scale=FALSE,trim=1
               ,stretch="positive",ramp=!FALSE)
   compose_close()
}
if (example2 <- TRUE) {
   b2 <- ursa_stack(a)
   compose_open(b2)
   compose_plot(b2,grid=FALSE,coast=FALSE,labels=5,trim=2,las=0)
   compose_close()
}
```

---

create_envi *Create ENVI or GDAL files on disk*

Description

`create_envi` creates ENVI binary and header files on disk. ENVI binary file is filled by blank (zero) values.
`create_gdal` is just an entry for GDAL wrapper; currently via internal ENVI implementation.

Usage

```
create_gdal(x, ...)

create_envi(x, ...)
```

Arguments

x	Filename, or any refenerce object to help assign properties of new ENVI file. Can be missed.
...	Use `name = value` sequence. Properties of new ENVI file are extracted from keywords in 'name' and data types of 'value'.

Details

Prior **ursa** version < 3.10, `create_gdal()` used classes and methods from package **rgdal**. Currenty, alternatives are not found for complete replacement of **rgdal**. At the present, ENVI binary and header are created, firstly, and `close()` transforms to desired GDAL format, finally.

`create_envi` and `create_gdal` use parameters of grid (boundary box, cell size, projection) from reference object of class `ursaRaster` in argument `x` or calls `session_grid`. You may specify values of GDAL or ENVI binary file later using `[<-`. If `x` is object of class `ursaRaster` then metadata parameters (interleave, data type, ignore value, etc) are inherited.

Keywords:

- `fname` - character. File name for created GDAL or ENVI file.

  For `create_envi` *only*: If `compress` of `connections` is not specified then example for "fileout" file name:
  - "fileout" - If external 'gzip' is found then "fileout.envigz" is created else "fileout.envi"
  - "fileout.envi" - "fileout.envi" is created without any compression.
  - "fileout." - "fileout" is created without any compression.
  - "fileout.bin" - "fileout.bin" is created without any compression.
  - "fileout.img" - "fileout.img" is created without any compression.
  - "fileout.dat" - "fileout.dat" is created without any compression.
- `driver` - character. *For* `create_gdal` *only*. Which GDAL driver is used.
- `layername` - character of length>=1. Layernames ('Band name' in ENVI header file)
- `bandname` - character of length>=1. Layernames ('Band name' in ENVI header file)
- `name` - character of length>=1. Layernames ('Band name' in ENVI header file)
- `nodata` - integer or numeric. Value in GDAL or ENVI binary file, which is interpretted as `NA` in R
- `ignore` - integer or numeric. Value in GDAL or ENVI binary file, which is interpretted as `NA` in R
- `ignorevalue` - integer or numeric. Value in GDAL or ENVI binary file, which is interpretted as `NA` in R
- `bg` - integer or numeric. Value in GDAL or ENVI binary file, which is interpretted as `NA` in R
- `connection` - character. *For* `create_envi` *only*. `connections` for ENVI binary file.

  Valid values are:
  - "gz" - connection is "gzfile"
  - "bz" - connection is "bzfile"
  - "xz" - connection is "xzfile"
  - "file" - connection is "file"
- `interleave` - character. Interleave. Valid values are "bsq", "bil", "bip". For `create_gdal` and `driver="GTiff"` valid values are "bsq" and "bil".
- `datatype` - character or integer (numeric). Data type.

  Valid values are:

  - 1, "byte", "Byte", "UInt8" = Byte: 8-bit unsigned integer
  - 2, "integer", "Int16" = Integer: 16-bit signed integer
  - 3, "Int32" = Long: 32-bit signed integer
  - 4, "real", "float", "Float32" = Floating-point: 32-bit single-precision
  - 5, "Float64" = Double-precision: 64-bit double-precision floating-point
  - 11, "UInt8" = Byte: 8-bit signed integer. **Not in specification.** Only for use with this package.
  - 12, "UInt16" = Integer: 16-bit unsigned integer
  - 13, "UInt32" = Long: 32-bit unsigned integer

  Specification https://envi.geoscene.cn/help/Subsystems/envi/Content/ExploreImagery/ENVIHeaderFiles.htm is used.

- `byteorder` - numeric (integer). Byte order.
- `bands` - numeric(integer). Number of bands/layers
- `nband` - numeric(integer). Number of bands/layers
- `nlayer` - numeric(integer). Number of bands/layers
- `layers` - numeric(integer). Number of bands/layers
- `compress` - integer (numeric) or logical. *For* `create_envi` *only*. Should ENVI binary file be compressed after closing connection.
- `wkt` - integer (numeric) or logical. Forced adding 'coordinate system string' to ENVI header file
- `ext` - character. *For* `create_envi` *only*. Extension of ENVI binary file. For extensions not in `c("envi","bin","dat","img")` list

If file name is unknown, then random file name is used with informing via `message()`.

Value

Object of class `ursaRaster` with opened connection of GDAL or ENVI binary file.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

`ursa_new` creates object of class `ursaRaster` in memory and allows to assign values at once.

Use `session_grid` to check or specify parameters of grid before calling `create_envi`.

Use `[<-` to assign values to ENVI binary file after calling `create_envi`.

Use `close` (or `close_envi`) to close `connections`.

Examples

```
session_grid(NULL)
a <- create_envi()
fname <- a$con$fname
dir(pattern=basename(envi_list(fname)))
close(a)
invisible(envi_remove(fname))

a <- create_envi("exam1",layername=paste("Band",1:5)
                 ,ignorevalue=99,datatype="Int16",interleave="bil")
ursa_info(a)
print(a[])
close(a)
invisible(envi_remove("exam1"))
```

---

cubehelix *Generate "cubehelix" palette.*

Description

cubehelix returns set of RGB colours, which are screen display of intensity images

Usage

```
cubehelix(n, value = numeric(), weak = NA, rich = NA, rotate = NA, hue = NA, gamma = 1,
          dark = NA, light = NA, bright = NA, inv = NA, verbose = NA)
```

Arguments

n	Positive integer. Length of returned color vector. If n is missing and length of value is positive, then length of value. If missing n and empty value, then n=256.
value	Numeric vector of values, which are associated with a palette. If both positive and negative values are in this vector, then divergence color palette is returned. Default in numeric of length zero (unspecified).
weak	Numeric. The angle (in degrees) of the helix for color with light intensity. If both rich and weak are specified, the rotate is defined as difference between rich and weak. If all weak, rich and rotate are unspecified, then random values are used. Default is NA (unspecified).
rich	Numeric. The angle (in degrees) of the helix for color with dark intensity. If both rich and weak are specified, the rotate is defined as difference between rich and weak. If all weak, rich and rotate are unspecified, then random values are used. Default is NA (unspecified).
rotate	Numeric. The angle of rotation (in degrees) of the helix over the scale; can be negative. If rotate and weak are specified, then rich is defined as sum of weak and rotate. If rotate and rich are specified, then weak is defined as difference between rotate and weak. If all weak, rich and rotate are unspecified, then random values are used. Default is NA (unspecified).

hue	Non-negative numeric. Saturation of color. hue=0 gives pure greyscale. If unspecified, then random value in interval [0.9, 1.5] is used. Default is NA (unspecified).
gamma	Numeric. Power of intensity. Intensity is between dark and light, which are normalized to interval [0, 1]. gamma changes normalized intensity to intensity^gamma. Default is 1.
dark	Positive numeric in interval between 0 and 255. The intensity of the darkest color in the palette. For light backgrounds default is 63. For dark backgrounds default is 14 (inverse order with light).
light	Positive numeric in interval between 0 and 255. The intensity of the lightest color in the palette. For light backgrounds default is 241, for dark backgrounds default is 192 (inverse order with dark).
bright	Positive numeric in interval between 0 and 255. Value for equal intensity for dark and light in the palette. Applied only for both dark=NA and light=NA.
inv	Logical. Inversion of color intensity. If TRUE then color vector is reversed before return. Default is FALSE.
verbose	Logical. Value TRUE provides information about cube helix on console. Default is NA, which is interpreted as FALSE.

Details

This is modified source code of function cubeHelix() from package **rje** under GPL>=2 license.

The palette design is oriented that figures can be printed on white paper. Under this assumption, light color is for small values, and dark color is for big values. In some computer vision and GIS software black background is used, and in this case light color for big values, and dark color of small values looks more naturally. For some thematic maps big values are light, and small values are small (for example, sea ice concentration: open water is blue, close ice is white). RGB and Grayscale remote sensing and photo imagery use light colors for strong signal, and dark colors for weak signal.

Light background is default for figure (specified by argument background in function compose_open).

The palette divergency can be defined only if value is specified. If all values are positive, or all values are negative, then returned palette is not drivergent. For divergent palettes the helix sequence is continuous.

If dark and lihgt are unspecified, the color contrast bewteen dark and light drops on reducing number of colors in returned vector.

Value

Vector of RGB color specification.

Acknowledgements

Dave Green, Robin Evans

Author(s)

Dave Green

Robin Evans

Nikita Platonov <platonov@sev-in.ru>

References

Dave Green's 'cubehelix' colour scheme.

Green, D. A., 2011, 'A colour scheme for the display of astronomical intensity images', Bulletin of the Astronomical Society of India, 39, 289. http://astron-soc.in/bulletin/11June/289392011.pdf (pre-print at 'arxiv.org')

`rje::cubeHelix()`; **rje** at CRAN: https://CRAN.R-project.org/package=rje

Examples

```
session_grid(NULL)
set.seed(352)
session_grid(regrid(mul=1/16))
a <- ursa_dummy(3,min=0,max=255)
b4 <- b3 <- b2 <- b1 <- vector("list",length(a))
for (i in seq_along(b1)) {
   b1[[i]] <- colorize(a[i],pal=cubehelix(11,weak=45*i,rotate=+270),ncolor=11)
   b2[[i]] <- colorize(a[i],pal=cubehelix(11,weak=45*i,rotate=-270),ncolor=11)
   b3[[i]] <- colorize(a[i]-127,pal=cubehelix)
   hue <- sample(seq(2)-1,1)
   s <- ifelse(hue==0,NA,runif(1,min=91,max=223))
   b4[[i]] <- colorize(a[i]-127,pal=cubehelix,pal.hue=hue,pal.dark=s,pal.light=s)
}
display(c(b1,b2),layout=c(2,NA),decor=FALSE)
display(c(b3,b4),layout=c(2,NA),decor=FALSE)
```

---

dim *Dimension of multiband raster image*

Description

Retrieve the dimension of an object of class `ursaRaster`. The replacement function is dummy; it doesn't change raster dimension.

Usage

```
## S3 method for class 'ursaRaster'
dim(x)
## S3 replacement method for class 'ursaRaster'
dim(x) <- value
```

Arguments

x	Object of class ursaRaster
value	Any. Ignored

Details

Use extract operator [] and combine function c to change third (e.g., temporal) dimension of raster.
Use regrid function to change grid parameters and to resize/resample raster into new grid.

Value

The 'Extract' function dim returns named integer vector of length three: 1) number of lines/rows, 2) number of samples/columns, 3) number of bands/channels/layers.
The 'Replacement' function dim<- returns ursaRaster object without changes.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/16))
a <- ursa_dummy(nband=3)
ursa_info(a)
print(dim(a))
dim(a) <- c(25,00,34)
print(dim(a))
b <- create_envi("tmp1",bandname=letters[1:5],compress=FALSE)
print(dim(b))
close(b)
envi_remove("tmp1")
```

---

discolor *Destroy color table for raster images.*

Description

If raster's categories are integer or numeric, then raster values are restored from names of categories. Otherwise only category names are dropped.

Usage

```
discolor(obj, nodata = NA)
```

Arguments

obj	Object of class ursaRaster
nodata	Numeric. Flag value for "no-data". If NA, then no-data values are missed. Default is NA.

Value

Object of class ursaRaster without color table.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
a <- colorize(pixelsize(),ncolor=7)
print(ursa_colortable(a))
print(a)
b <- discolor(a)
print(ursa_colortable(b))
print(b)
```

---

display *Plot raster image(s) in the PNG format.*

Description

High-level function to create multi-panel layout of images and to display with decoration (gridlines, coastlines, scalebar, colorbars) in the PNG format. It is an aggregator of low-level functions for typical plotting.

Usage

```
display(obj, ...)
```

Arguments

obj	Object of class ursaRaster or list of ursaRaster objects.

...	Passed to either display_brick or display_stack or display_rgb functions and further to hierarchy of plotting functions:
	• compose_open
	  – compose_design
	• compose_plot
	  – panel_new
	  – panel_raster

- panel_decor
  - panel_graticule
  - panel_coastline
  - panel_scalebar
  - panel_annotation
- compose_legend

- compose_close

Details

If argument obj is missing (e.g, calling display() without parameters) then plotting the sessional CRS with blank image.

If argument obj is list of ursaRaster objects (or object of class ursaStack) then display_stack is called.

If argument obj is object of class ursaRaster and has 3 or 4 bands and values in each band are integer and in interval between 0 and 255, then display_rgb is called.

If argument obj is object of class ursaRaster then firstly internal test is applied to detect either image's bands contains homogeneous information (raster brick) or heterogeneous information (raster stack). Then either display_brick or display_stack is called. This test is rough due to unknown data origin. It is supposed to adjust kind of plotting by means of direct specification of display_brick or display_stack.

Value

Returned value from either display_brick or display_stack or display_rgb functions.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

display_brick, display_stack, display_rgb

R-styled plotting: plot, image

Examples

```
session_grid(NULL)
set.seed(500)
a.brick <- a.stack <- ursa_dummy(nband=3,min=0,max=255,mul=1/16)
a.stack[2] <- a.stack[2]/10
a.stack[3] <- sqrt(a.stack[3])
a.rgb <- as.integer(round(a.brick))
print(a.brick)
print(a.stack)
print(a.rgb)
display(a.brick,decor=FALSE)
display(a.stack,decor=FALSE)
display(a.rgb)
```

`display_brick` *Plot multi-band homogenous raster image in the PNG format.*

Description

Raster image is forced to be interpreted as homogenuous (having the same units). It implies creating multi-panel layout with multiple colorbars.

Usage

```
display_brick(obj, ...)
display_homo(obj, ...)
```

Arguments

`obj`	Object of class `ursaRaster` or `list` of `ursaRaster` objects.
`...`	Passed to hierarchy of plotting functions:

- `compose_open`
  - `compose_design`
- `compose_plot`
  - `panel_new`
  - `panel_raster`
  - `panel_decor`
    - `panel_graticule`
    - `panel_coastline`
    - `panel_scalebar`
    - `panel_annotation`
  - `compose_legend`
- `compose_close`

Details

If argument `obj` is `list` of `ursaRaster` objects (or object of class `ursaStack`) then `obj` is coerced to class `ursaRaster` ('stack' is coerced to 'brick').

`display_homo` is a synonym to `display_brick`. It is introduced to emphasize the plotting of homogenous object.

Value

Function returns `NULL` value.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

display, display_stack, display_rgb

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=3,min=0,max=250)
a[2] <- -a[1]
a[3] <- sqrt(a[1])
a2 <- ursa_stack(a)
print(a2)
display(a2) # likely 'display_stack' will be called
display_brick(a2,stretch="eq",labels=c(-150,-100,0,10,12,20,100,150))
```

---

display_rgb *Plot RGB (RGBA) color composition in the PNG format.*

Description

Raster images are forced to be interpreted as color composition with 3 (RGB) or 4 (RGBA) channels. Values should be in the range between 0 and 255.

Usage

```
display_rgb(obj, ...)
```

Arguments

obj	Object of class ursaRaster or list of ursaRaster objects.
...	Passed to hierarchy of plotting functions:

- compose_open
  - compose_design
- compose_plot
  - panel_new
  - panel_raster
  - panel_decor
    - panel_graticule
    - panel_coastline
    - panel_scalebar
- compose_close

Details

If argument obj is list of ursaRaster objects (or object of class ursaStack) then obj is coerced to class ursaRaster ('stack' is coerced to 'brick').

Colorbar is not plotted.

By default, the created PNG has 24 bits per pixel. This is equal to parameter bpp=24 (compose_close). It is allow to specify other value, e.g., display_rgb(a,bpp=8).

By default, labels of gridlines are located in bottom and left sides of the panel with raster. This is equal to parameter margin=c(TRUE,TRUE,FALSE,FALSE) (panel_graticule). It is allow to specify other value, e.g., display_rgb(a,margin=T).

Currently, for color compositions the argument useRaster (panel_raster) is introduced to fix possible coordinate mismatch for Cairo-devices, but have never used.

Value

Function returns NULL value.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

display, display_brick, display_stack

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=3)
display_rgb(a)
```

---

display_stack *Plot multi-band heterogenous raster images in the PNG format.*

Description

Raster images are forced to be interpreted as heterogenuous (having the different units). It implies creating multi-panel layout with multiple colorbars.

Usage

```
display_stack(obj, ...)
display_hetero(obj, ...)
```

Arguments

obj	Object of class ursaRaster or list of ursaRaster objects.
...	Passed to hierarchy of plotting functions:

- compose_open
  - compose_design
- compose_plot
  - compose_panel
    - panel_new
    - panel_raster
    - panel_decor
      - panel_graticule
      - panel_coastline
      - panel_scalebar
    - panel_annotation
  - compose_legend
    - legend_colorbar
- compose_close

Details

If argument obj is object of class ursaRaster then obj is coerced to list of ursaRaster objects ('brick' is coerced to 'stack').

The plot layout is either two-columns or two-rows. Extent of coordinate grid has a form of rectangle. The layout selection depends on ratio of rectangle's sides. For single-column design use parameter layout=c(NA,1L). e.g., display_brick(a,layout=c(NA,1)), for single-row design use parameter layout=c(1,NA). The same is for forcing of two-columns (layout=c(NA,2L)) and two-rows layouts (layout=c(2L,NA)). Other layouts are not applicable for multiple colorbars.

display_hetero is a synonym to display_stack. It is introduced to emphasize the plotting of complex object with heterogeneous elements, for example, having different units.

Value

Function returns NULL value.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

display, display_brick, display_rgb

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=3)
display_stack(a)
```

envi_files *ENVI File Manipulation*

Description

Management of ENVI files similar to functions of OS file manager.

Usage

```
envi_exists(pattern = ".+", path = ".", all.files = FALSE, full.names = TRUE,
           recursive = FALSE, ignore.case = TRUE, exact = FALSE)
envi_list(pattern = ".+", path = ".", all.files = FALSE, full.names = recursive,
          recursive = FALSE, ignore.case = TRUE, exact = FALSE)
envi_remove(pattern = ".+", path = ".", all.files = FALSE, full.names = recursive,
            recursive = FALSE, ignore.case = TRUE, verbose = FALSE)
envi_copy(src, dst, overwrite = TRUE)
envi_rename(src, dst, overwrite = TRUE)

ursa_exists(fname)
```

Arguments

pattern	Either filename (like basename function) or mask in format of regular expressions or full path name.
path	Either path name (like dirname function) or ignored if pattern describes full path.
all.files	A logical value. If FALSE, only the names of visible files are returned. If TRUE, all file names will be returned. Similar to all.files argument in list.files function
full.names	A logical value. If TRUE, the directory path is prepended to the file names to give a relative file path. If FALSE, the file names (rather than paths) are returned. Similar to full.names argument in list.files function
recursive	Logical. Should the listing recurse into directories? Similar to recursive argument in list.files function
ignore.case	Logical. Should pattern-matching be case-insensitive? Similar to ignore.case argument in list.files function
exact	Logical. Attempt to cancel regular expressions.
verbose	Logical. TRUE provides some additional information on console.
src	Strings of length 1 or more. Name or directory name or path of source ENVI files.
dst	Strings of length 1 or more. Name or directory name path of destination ENVI files. Length is assuming to be equal to length of src
overwrite	Logical. TRUE overwrites destinations ENVI files. FALSE does nothing if destinaton ENVI file exists.
fname	Character. Full file name or file pattern with file path.

Details

Functions do not view content of any files. The major identifier of ENVI files in file system is ENVI header (*.hdr) file. Binary file is searching along 1) original *.envi, *.bin, *.img, *.dat extensions, 2) externally packing *.gz. *.bz2, *.xz extensions, or 3) packed by this package *.envigz, *.bingz extensions. Functions `envi_copy()` and `envi_rename()` keeps original extension of ENVI binary file; use `file.rename` to rename ENVI binary file.

Value

`envi_exists()` returns integer number of found ENVI files.

`envi_list()` returns character vector of found ENVI files.

`envi_remove()` returns character vector of deleted ENVI files.

`envi_copy()` returns 0L.

`envi_rename()` returns value of `file.rename`, which is applied to objects in file system.

`ursa_exists()` returs `TRUE` if any *.tif, *.tiff, *.bin, *.hfa file is found.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
wd <- setwd(tempdir())
a1 <- create_envi("tmp1.envi")
a2 <- create_envi("tmp2.")
close(a1,a2)
envi_list()
envi_copy("tmp1","tmp3")
envi_copy("tmp2","tmp4")
envi_list()
envi_rename("tmp3","tmp5")
envi_list()
envi_exists("nofilewithsuchname")
envi_exists("tmp[34]")
envi_remove(".+")
envi_list()
setwd(wd)
```

Extract *Extract portion of raster images*

Description

This operator is used to get single band or subset of bands from multi-band `ursaRaster` object. Another purpose is get portions of data including data reading from files.

Usage

```
## S3 method for class 'ursaRaster'
x[i, j, ..., drop = FALSE]
```

Arguments

x	ursaRaster object
i	Integer or character. If integer, then band index, specifying bands to extract. If character, either list of band names or character sting for regular expression to match band index. In the *(spatial, temporal)* interpretation of ursaRaster object j points to *temporal* component.
j	Integer. Line index, specifying lines to extract.
...	Mentioned for consistence with internal generic function [. Use regexp=FALSE for matching by match, and regexp=TRUE for matching by Perl-compatible regexps case insensitive grep. Default is FALSE.
drop	Not used. For consistence with generic function.

Details

Operator \sQuote{[} is high-level implementation for data reading. If x$value item is not applicable, then value of ursaRaster is not in memory. In this case the controlled by i and j portion is read to memory. If both i and j are missing, then x[] reads all values from file.

x[,j] is appropriate for time series analysis and processing in the case bands have relation to *temporal* observation. Use regrid for geographical subset and cropping.

Value

ursaRaster object with extracter bands. Values ($value item) are in memory.

Warning

It is not allowed to read simultaneously portion of bands and portion of lines from file, *e.g.*,

```
x <- open_envi(fname)
y <- x[2:3,10:20]
close(x)
```

Such brunch is not implemented in code. You use one of the followed tricks:

```
x <- open_envi(fname)
y <- x[2:3][,20:30]
close(x)
```

or

```
x <- open_envi(fname)
y <- x[,20:30][2:3]
close(x)
```

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
## Prepare
session_grid(regrid(mul=1/8))
a <- pixelsize()
w <- c("Monday","Tuesday","Wednesday","Thursday","Friday","Saturday","Sunday"
      ,"MondayAgain")
b <- rep(a/mean(a),length(w))+seq(length(w))-1
bandname(b) <- w
nr <- ursa_rows(b)
bottom <- (as.integer(nr/2)):nr
write_envi(b,"tmp1",compress=FALSE,interleave="bil")

## Extract
print(b["Monday",regexp=TRUE])
print(b["Monday",regexp=FALSE])
print(b["s"])
print(b["^s"])
d1 <- b[6,bottom]
rm(b)

## Read from file
b <- open_envi("tmp1")
print(b[])
print(b[-c(6:8)])
d2 <- b[,bottom][6] ## don't use b[6,bottom]
close(b)
envi_remove("tmp1")

## Compare
print(d1)
print(d2)
```

---

focal_extrem *Extremal spatial filter for image*

Description

For each band and for each cell, depending of specification, function finds either minimal or maximal value inside of square window. *Focal* operation of map algebra.

Usage

```
focal_extrem(x, kind = c("min", "max"), size = 3, cover = 1e-06,
             fillNA = FALSE, saveMargin = TRUE, verbose = 0L)
```

```
focal_min(x, size = 3, cover = 1e-06, fillNA = FALSE, saveMargin = TRUE, verbose = 0L)
focal_max(x, size = 3, cover = 1e-06, fillNA = FALSE, saveMargin = TRUE, verbose = 0L)
```

Arguments

x	Object of class ursaRaster.
kind	Character. What kind of extremum is required. Allowed values "min" or "max".
size	Positive numeric. Odd values (3, 5, 7, ...) are allowed, but if other value is specified, then it expanded to the next odd value not less than original value. Default is 3L.
cover	Numeric. 0<=cover<=1. Quota for NA values in the focal window in relation to the squared size of the focal window. Quota exceeding leads to recording NA value in the cell. Default is cover=1e-6.
fillNA	Logical. If TRUE then only NA values of source image can be changed, and non-NA values of source image are kept without changes. It may provide less reducing of spatial resolution in the task of spatial interpolation. Default is FALSE.
saveMargin	Logical. If TRUE then adaptive window size is used for cells, where original window goes over image boundary. If FALSE then image is expanded to the half size of focal window by NA values and argument cover is applied to this expanded part. Default is TRUE.
verbose	Integer of 0L, 1L, or 2L, or logical, which is coerced to integer. The level of verbosity. Values >0 provide some additional information on console, verbose=1L is less detailed, verbose=2L is more detailed. Default is 0L.

Details

focal_min(x,...) is a wrapper to focal_extrem(x,"min",...)
focal_max(x,...) is a wrapper to focal_extrem(x,"max",...)

Value

Object of class ursaRaster with the same number of bands as in input raster.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

Other focal operations: focal_mean, focal_median.

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=2,mul=1/8,elements=32)
a[a<80] <- NA
b.min <- focal_extrem(a,"min",size=4,cover=0.5,verbose=1L)
b.max <- focal_extrem(a,"max",size=4,cover=0.5,verbose=1L)
print(list(src=a,min=b.min,max=b.max,dif=b.max-b.min))
```

`focal_mean` *Low-pass spatial filter for image.*

Description

Low-pass filtering by a square window in the image processing. *Focal* operation of map algebra. Weight of pixels is proportional to cell area inside of focal window.

Usage

```
focal_mean(x, size = 3.0, cover = 1e-06, fillNA = FALSE, saveMargin = TRUE
          ,noNA = TRUE, verbose = 0L)
```

Arguments

`x`	Object of class `ursaRaster`.
`size`	Positive numeric. Size of square focal window. Fractional values are allowed. If `size` is not odd (3, 5, 7, ...), then window size is expanded to the nearest odd value not less than original value, and pixels on border are taken with the weight, which is proportional to the cell area inside of original size. Default `size=3`.
`cover`	Numeric. `0<=cover<=1`. Quota for `NA` values in the focal window in relation to all values. Values are taken with the weight proportional of cell areas inside of focal window. Quota exceeding leads to recording `NA` value in the cell. Default is `cover=1e-6`.
`fillNA`	Logical. If `TRUE` then only `NA` values of source image can be changed, and non-`NA` values of source image are kept without changes. It may provide less reducing of spatial resolution in the task of spatial interpolation. Default is `FALSE`.
`saveMargin`	Logical. If `TRUE` then adaptive window size is used for cells, where original window goes over image boundary. If `FALSE` then image is expanded to the half size of focal window by `NA` values and argument `cover` is applied to this expanded part. Default is `TRUE`.
`noNA`	Logical. If `TRUE` then `NA` values are transformed to numerical constant, which is interpreted as "no data" value. Filter without `NA` values has more perfomance, and generally filter with pre- and post-transformations of `NA` values have more perfomance too. Default is `TRUE`.
`verbose`	Integer of `0L`, `1L`, or `2L`, or logical, which is coerced to integer. The level of verbosity. Values `>0` provide some additional information on console, `verbose=1L` is less detailed, `verbose=2L` is more detailed. Default is `0L`.

Details

The reference is always central pixel, even if window size is even.

If `size=3` then multiplicator is `3^(-2)` and elements have equal weights:

```
     [,1] [,2] [,3]
[1,]    1    1    1
[2,]    1    1    1
[3,]    1    1    1
```

If `size=2` then multiplicator is `2^(-2)` and weights of elements are:

```
     [,1] [,2] [,3]
[1,] 0.25 0.50 0.25
[2,] 0.50 1.00 0.50
[3,] 0.25 0.50 0.25
```

If `size=3.4` then multiplicator is `3.4^(-2)` and weights of elements are:

```
     [,1] [,2] [,3] [,4] [,5]
[1,] 0.04 0.20 0.20 0.20 0.04
[2,] 0.20 1.00 1.00 1.00 0.20
[3,] 0.20 1.00 1.00 1.00 0.20
[4,] 0.20 1.00 1.00 1.00 0.20
[5,] 0.04 0.20 0.20 0.20 0.04
```

Value

Object of class `ursaRaster` with the same number of bands as in input raster.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=1,mul=1/8,elements=0)
a[a<80] <- NA
print(a)
b1 <- focal_mean(a,size=6,cover=0.5,saveMargin=FALSE)
b2 <- focal_mean(a,size=6,cover=0.5,saveMargin=TRUE)
b3 <- focal_mean(a,size=6,cover=0.5,saveMargin=TRUE,fillNA=TRUE)
print(b3-a)
display(c(a,b1,b2,b3),blank.angle=c(-45,45),blank.density=20)
```

---

focal_median *Median spatial filter for image*

Description

For each band and for each cell, function finds median value inside of square window. *Focal* operation of map algebra.

Usage

```
focal_median(x, size = 3, cover = 1e-06, fillNA = FALSE, saveMargin = TRUE, verbose = 0L)
```

Arguments

x	Object of class ursaRaster.
size	Positive numeric. Odd values (3, 5, 7, ...) are allowed, but if other value is specified, then it expanded to the next odd value not less than original value. Default is 3L.
cover	Numeric. 0<=cover<=1. Quota for NA values in the focal window in relation to the squared size of the focal window. Quota exceeding leads to recording NA value in the cell. Default is cover=1e-6.
fillNA	Logical. If TRUE then only NA values of source image can be changed, and non-NA values of source image are kept without changes. It may provide less reducing of spatial resolution in the task of spatial interpolation. Default is FALSE.
saveMargin	Logical. If TRUE then adaptive window size is used for cells, where original window goes over image boundary. If FALSE then image is expanded to the half size of focal window by NA values and argument cover is applied to this expanded part. Default is TRUE.
verbose	Integer of 0L, 1L, or 2L, or logical, which is coerced to integer. The level of verbosity. Values >0 provide some additional information on console, verbose=1L is less detailed, verbose=2L is more detailed. Default is 0L.

Value

Object of class ursaRaster with the same number of bands as in input raster.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

Other focal operations: focal_mean, focal_extrem.

Examples

```
session_grid(NULL)
a <- ursa_dummy(1,mul=1/8,elements=0,bandname="src")
a[a<80] <- NA
bF <- c(fillNA.F=focal_median(a[1],size=5,cover=0.5,fillNA=FALSE))
bT <- c(fillNA.T=focal_median(a[1],size=5,cover=0.5,fillNA=TRUE))
print(c(diff=bT-bF))
d <- c(a,bF,bT)
print(d)
display(d)
```

focal_special *Custom spatial filtering for image*

Description

For each band and for each cell, function calculates value using specific matrix of square window. *Focal* operation of map algebra.

Usage

```
focal_special(x, type = c("custom", "gaussian", "laplacian", "osisaf",
                          "hires", "correl", "LoG", "sobel", "sobelG"),
              fmask = NULL, size = 3, alpha = 0.5, sigma = (size-1)/4,
             cover = 1 - 1e-06, fillNA = FALSE, saveMargin = FALSE, verbose = 0L)
```

Arguments

x	Object of class ursaRaster.
type	Character, which is checked by match.arg.
fmask	Numeric square matrix. Filter mask. If NULL then matrix(1,ncol=1) is used. Default is NULL.
size	Numeric. Diameter of circuled filter mask. Coerced to the nearest odd value not less than original value.
alpha	Nimeric. Parameter alpha for "Laplacian", "LoG", "hires", "correl" filters. Ignored for others. Default is 0.5.
sigma	Numeric. Parameter sigma for "Gaussian", "LoG" filters. Ignored for others. Default is 0.5.
cover	Numeric. 0<=cover<=1. Quota for NA values in the focal window in relation to the squared size of the focal window. Quota exceeding leads to recording NA value in the cell. Default is cover=1-1e-6.
fillNA	Logical. If TRUE then only NA values of source image can be changed, and non-NA values of source image are kept without changes. It may provide less reducing of spatial resolution in the task of spatial interpolation. Default is FALSE.
saveMargin	Logical. If TRUE then adaptive window size is used for cells, where original window goes over image boundary. If FALSE then image is expanded to the half size of focal window by NA values and argument cover is applied to this expanded part. Default is FALSE.
verbose	Integer of 0L, 1L, or 2L, or logical, which is coerced to integer. The level of verbosity. Values >0 provide some additional information on console, verbose=1L is less detailed, verbose=2L is more detailed. Default is 0L.

Details

Developed under impression from Matlab's "fspecial".

- `type="custom"`
  Filter mask (argument `fmask`) should be specified manually.
- `type="gaussian"`
  Gaussian filter. For cascade filtering (sequence of increasing or decreasing window `size`) `sigma=(size-1)/4` produces the same distribution density relative to window size. If `sigma` is high but not `Inf` then it is low-pass filter with diameter=`size` of circular focal window.
- `type="laplacian"`
  Laplacian filter. Only `size=3` makes sence. Any `size` is coerced to `size=3`.
- `type="osisaf"`
  Filter for edge detection. Only `size=5` makes sence. Any `size` is coerced to `size=5`. *TODO (pl): reference*

```
-0.0625 -0.0625 -0.0625 -0.0625 -0.0625
-0.0625  0.1250  0.1250  0.1250 -0.0625
-0.0625  0.1250  0.0000  0.1250 -0.0625
-0.0625  0.1250  0.1250  0.1250 -0.0625
-0.0625 -0.0625 -0.0625 -0.0625 -0.0625
```

- `type="hires"`
  Filter for unsharping. Only `size=3` makes sence. Any `size` is coerced to `size=3`.

```
-alpha   alpha-1 -alpha
 alpha-1 alpha+5  alpha-1
-alpha   alpha-1 -alpha
```

- `type="correl"`
  Filter for contrast increasing. Only `size=3` makes sence. Any `size` is coerced to `size=3`.

```
           alpha^2    -alpha*(1+alpha^2)              alpha^2
-alpha*(1+alpha^2)         (1+alpha^2)^2    -alpha*(1+alpha^2)
           alpha^2    -alpha*(1+alpha^2)              alpha^2
```

- `type="LoG"`
  Laplacian of Gaussian. Filter for edge detection. `sigma` is used, `alpha` is ignored.
- `type="sobel"`
  Two-directional Sobel filtering. Only `size=3` makes sence. Any `size` is coerced to `size=3`.
- `type="sobelG"`
  Sobel gradient. Only `size=3` makes sence. Any `size` is coerced to `size=3`.

Value

Object of class `ursaRaster` with the same number of bands as in input raster.

Warning

Laplacian of Gaussian filter (`type="LoG"`) is not implemented clearly due to applying continuous-valued formula to discrete matrix.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

References

TODO(pl): at least reference to 'osisaf'.

See Also

Other focal operations: focal_mean, focal_median, focal_extrem.

Examples

```
session_grid(NULL)
v <- round(runif(8,min=-1,max=1),3)
customFilter <- matrix(c(v[1:4],-sum(v),v[5:8]),ncol=3)
a <- ursa_dummy(1,mul=4/8,elements=32)
tpList <- eval(formals("focal_special")$type)
res <- c(src=a,as.ursa(bandname=tpList))
for (tp in tpList) {
   message(tp)
   res[tp] <- focal_special(a,tp,fmask=customFilter,size=11,sigma=1,alpha=0.8
                           ,saveMargin=0,verbose=2L)
}
print(res)
display(res,decor=FALSE)
```

---

get_earthdata *Retrive data from Global Imagery Browse Services (GIBS) using API for Developers*

Description

get_earthdata allows retrieving georeferences optical satellite images of low and moderate spatial resolution (up to 250m per cell) using GIBS API for Developers.

Usage

```
get_earthdata(bbox = NA, res = c("2km", "1km", "500m", "250m"),
              date = NA, product = "", geocode = "",
              expand = 1.05, border = 0, display = FALSE,
              cache = NA, verbose = FALSE)
```

Arguments

bbox	Numeric of length 4 or character. Spatial extent in the notation `c(minx,miny,maxx,maxy)`. Can be in utits of meters or degrees. If all absolute values are less than 360, then units are in degrees and projection is EPSG:3857, else units are in meters and projection is EPSG:3413. If `bbox=NULL`, then function return list of available products. If `bbox=NA` then boundary box is attempted for taking from session grid. If character, then boundary box is taken from geocoding. Default is region of Vaigach Island.
res	Character or numeric. Parameter, which is responsible for dimension of output raster image. If character, then zoom is selected using keyword list `c("2km", "1km", "500m", "250m")` for EPSG:3413. If `res<10` then it is interpreted as zoom for Web Map Tile Service (WMTS). If `res>100` then `res` is interpreted as preffered image dimension. If `res=NA` then `res=480L`.
date	Character or `"Date"` object. Date for image retrieving. Default is `Sys.Date()-1L`.
product	Character of integer. Data product form GIBS. Currently only MODIS-oriented (corrected reflectance) products are available: 1. "MODIS_Aqua_CorrectedReflectance_Bands721" 2. "MODIS_Terra_CorrectedReflectance_Bands721" 3. "MODIS_Aqua_CorrectedReflectance_TrueColor" 4. "MODIS_Terra_CorrectedReflectance_TrueColor" 5. "VIIRS_SNPP_CorrectedReflectance_TrueColor" 6. "Coastlines" Please check actual list by calling `get_earthdata(bbox=NULL)`. If numeric, then index of item among available products. Regular expressions can be used to simplify value of product, e.g., case-insensitive "aqua 721", "terra truecolor", "suomi", "SNNP".
geocode	Character. Keyword for geocode service. Valid values are `"google"`, `"nominatim"`. Default is `""`; several services are considered in the case of failure.
expand	Numeric. Multiplier for plotting panel zoom in relation to extent of plotting geometry. Ignored if geocoding is not applied. Default is `1.05`.
border	Integer. Value in pixels of fixed margins around plotting geometry. Ignored if geocoding is not applied. Default is `0L`.
display	Logical. Value `TRUE` forces to display image instead of return it. Default is `FALSE`.
cache	Logical. Is cache used? Default is `NA`, which is interpreted as `TRUE` for any requested date excepting not late time of today (approximately 17:00 UTC).
verbose	Logical. Value `TRUE` may provide some additional information on console. Default is `FALSE`.

Details

Argument `method="libcurl"` is used in function `download.file` for tile downloading. Please check `capabilities("libcurl")`.

Valid zoom values (e. g., specified via `res` argument) are 3:6 for EPSG:3413 and 0:8 for EPSG:3587.

Longitude 180 degrees has a seam in EPSG:3857 (e.g., see `bbox=c(170,68,-170,73)` and `bbox=c(-1600000,1308000,-13` for Wrangel Island. If region crosses longitude 180 degrees in EPSG:3857, then the prior day is taken for Western Hemisphere.

Value

If `bbox=NULL`, then character vector of available products.

If `display=FALSE` then object of class `ursaRaster` with RGBA image.

If `display=TRUE` then returned value of `display_brick`.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

References

GIBS API for Developers

Examples

```
session_grid(NULL)
pr <- get_earthdata()
print(pr,quote=FALSE)

 ## internet connection is required -- begin
a1 <- get_earthdata(bbox=c(2000000,400000,2300000,700000))
display(a1)

 ## internet connection is required -- end
a2 <- get_earthdata(product=2
                  # ,date=Sys.Date()-7L ## empty tiles for winter polar regions
                   ,date=as.Date(format(Sys.Date()-365L,"%Y-06-15"))
                   ,res=7,bbox=c(57.8,69.4,62.3,70.8))
display(a2)
```

`glance` *Command line utility for spatial view of raster or vector GIS file.*

Description

`glance` is a parser of command line arguments for non-public function `.glance`, which creates multi-panel plots for each attribute of vector file or for each band of raster file.

Usage

```
glance(...)

# non-public
.glance(dsn, layer = ".*", grid = NULL, field = ".+", size = NA, expand = 1,
        border = 27, lat0 = NA, lon0 = NA, resetProj = FALSE, resetGrid = FALSE,
        style = "auto", feature = c("auto", "field", "geometry"), alpha = NA,
        basemap.order = c("after", "before"), basemap.alpha = NA,
        engine = c("native", "sp", "sf"), geocode = "", place="",
       area = c("bounding", "point", "shape"), zoom = NA, gdal_rasterize = FALSE,
        silent = FALSE, verbose = FALSE, ...)
```

Arguments

dsn	Character or object of either ursaRaster, Spatial, or sf classes. If character, then data source name (interpretation varies by driver - for some drivers, dsn is a file name, but may also be a folder, or contain the name and access credentials of a database).
layer	Character or integer. If integer, then layer index. If character, then pattern (regular expressions) to recognize layer by name. Only one layer selection is allowed. If selected more then one layer, the error message contains indices and names of layers. Usually, datasets (e. g., "ESRI Shapefile") have only one layer. Default is ".*"; interpreted as all layers.
grid	Object of class ursaGrid or NULL. Reference CRS and boundary box for visualization. If NULL, then CRS and boundary box are zoomed to layer. Default is NULL.
field	Character. Pattern for field (attribute, column,...) selection by name using regular expressions. Multiple selection is allowed. Default is ".+"; all fields.
size	Integer of length 1 or 2 or character of length 1. Size of plotting panel in pixels. If character, then parsed to integer of length 1 or 2. Length 2 is used only for web cartography. If length 1, then size defines width of panel, and height is defined automatically. If integer, then width of panel for plotting in pixels. Default is NA; for web cartogrpaphy value of maximal size of static maps, and 640 for other cases.
expand	Numeric. Multiplier for plotting panel zoom in relation to extent of plotting geometry. Default is 1.0.
border	Integer. Value in pixels of fixed margins around plotting geometry. Default is 27L.
lat0	Numeric. Parallel os zero distortion. If NA, then parallel os zero distortion is determined from object geometry. Actual for "+proj=stere" projections. Default is NA.
lon0	Numeric. Central meridian, which have vertical direction on the plot. If NA, then central meridian is determined from object geometry. Default is NA.
resetProj	Logical. Value TRUE overwrites projection of vector file. Default is FALSE.

`resetGrid` Logical. If `TRUE`, then session grid is ignored, and new session grid is assigned from input file. If `FALSE`, then input file is nested in the session grid.

`style` Character. Either projection class or source of web-catrogrpaphy for basemap. Specified by a sentence of words separated by spaces.

- Projection class
  Valid values are `"stere"`, `"laea"`, `"merc"`, `"longlat"`. Default is keyword `"auto"`; use object projection, if this projection differs from projection class `"+longlat"`, otherwise, projection (`"stere"` or `"merc"`) is determined internally.
- Web cartography.
  - Static map
    Valid values are `"google"`, `"openstreetmap"`, `"sputnikmap"`. Static maps have priority over tile services. however additional word `"static"` can be specified in the sentence, e.g., `"openstreetmap static"` or `"static google"`. Additional parameters for request to web-script can be added in the sentence in the form `"argument1=value1 [argument2=value2]"`, e.g., `style="google static maptype=terrain language=ru-RU scale=2"`.
  - Tile service
    Supported tile services can be returned by calling of non-public function `ursa:::.tileService()` without arguments. Valid values are `"mapnik"`, `"cycle"`, `"transport"`, `"mapsurfer"`, `"sputnik"`, `"thunderforest"`, `"carto"`, `"kosmosnimki"`, etc.

  By default, if data has no data fields (e. g., geometry only), then basemap is drawn in color, else in grayscale. Adding word `"color"` (or `"colour"`) to the sentence forces to use colored basemap. Adding word `"gray"` (or `"grey"`, `"greyscale"`, `"grayscale"`) to the sentence forces to use colored basemap.
  The order of words in the sentence is any.

Keywords `"google"`, `"openstreetmap"` force to use "Google Static Map" or "OpenStreetMap static map images" for basemap; the resulted projection has class `"+proj=merc"`.

`feature` Character. Appearance of visualization. If `"field"` then data of each field is plotted on separate panel (number of panels is equal to number of columns in attribute table). If `"geometry"` then each feature is plotted on separate panel (number of panels is equal to number of rows in attribute table). Default is `"auto"`; if intersects of features are found, then `"geometry"` is used, else `"field"`.

`basemap.order` Character. The order of basemap layer rendering in the case of web-cartography basemap.If `"before"`, then basemap is plotted before object plot. If `"after"`, then basemap is plotted over object.

`basemap.alpha` Character. The saturation of basemap in the case of web-cartography basemap. Default is `NA`; `basemap.alpha=0.5` for `basemap.order="before"` and `basemap.alpha=0.35` for `basemap.order="after"`.

`alpha` Character. The opacity of plotted object. Default is `NA`; 0.75 for `basemap.order="before"` in web-cartogrpaphy style, `1.00` - in all other cases.

`engine` Character keyword. Forcing to vector files processing by functions from package **sp** (`engine="sp"`) or package **sf** (`engine="sf"`, if **sf** is installed). Default is `"native"`; if `dsn` is `Spatial` object or if **sf** is not installed, then `"sp"` is used.

geocode	Character. Keyword for geocode service. Valid values are "google", "nominatim". If dsn is character and file dsn not found, then trying to interpret dsn as a request to geocode service. The output is only basemap of web cartogrpaphy. Default is ""; several services are considered in the case of failure. Is style is not specified, then "Google Static Map" is used for geocode="google", and "OpenStreetMap static map images" for geocode="nominatim".
place	Character. Type of geographical object (river, island) in the geocoding request. If geocode service is "nominatim", then place is searched among attributes "class" and "type". Default is ""; any object is acceptable.
area	Character. Keyword of spatial class of geocoded object. "bounding" is used for boundary box; "point" is used for point. Default value is extracted by match.arg(area).
zoom	Positive integer or character. Zooming if web-cartography is applied for basemap. If integer, then value of zoom for tile services and staticmap. If character, then "0" means zoom by default (defined internally), "+1" means increment on 1 of default zoom, "+2" means zoom increment on 2, "-1" means zoom decrement on 1, "-2" means zoom decrement on 2, *etc*. Default is NA; zoom is defined internally.
gdal_rasterize	Logical. If TRUE and GDAL utilities are in the system search path, then overlay for panels is formed via rastetization of vector file. GDAL utility "gdal_rasterize" is used. Note, that GDAL (system level) is optional for this package. Default is FALSE.
silent	Logical. Value TRUE cancels progress bar. Default is FALSE.
verbose	Logical. Logical. Value TRUE may provide some additional information on console. Default is FALSE.
...	glance: Arguments, which are passed to .glance or to display. .glance: Arguments, which are passed to static maps API, colorize, display, *etc*.

Details

Command line usage implies set of arguments using pair: argument name and argument value. and values in the format "[name1=]value1 [name2]=value2". No spaces around = (equal symbol). Argument name can be omitted, symbol = is omitted too. If argument value has spaces, then argument value should be surrounded by double quotes (fname="my test.shp"). If argument value is matched to R function, then such value should be surrounded by single quotes (layer='density').

Command line usage example: Rscript -e ursa::glance() 'final_more_than_032.sqlite' attr="select" resetProj=TRUE expand=1.5

For OS Windows, bat-file can be created for raster and vector file association: Rscript -e ursa::glance() %*

Command line usage implies external software for PNG view session_pngviewer(TRUE).

Value

glance returns integer: 0L - successful, 10L - call without arguments.

Note

Package **sp** is 'Suggested' for package **ursa**.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
f <- system.file("shape/nc.shp",package="sf")
glance(f,style="merc",field="(NAME|AREA|COUNT)")
cmd <- paste("Rscript --vanilla -e ursa::glance()",paste0("\"",f,"\"")
            ,"style=\"merc\"","field=\"74$\"")
cat(" --------- Try in command line: -----------\n")
message(cmd)
cat(" ----------- end of quoting ---------------\n")

## windows: figure will be opened using *.png file association
try(system(cmd,wait=FALSE))


a <- data.frame(lat=c(70.734,71.657),lon=c(178.577,-177.38),place="Wrangel Island")
if (requireNamespace("sp")) {
   sp::coordinates(a) <- ~lon+lat
   sp::proj4string(a) <- "EPSG:4326"
} else {
   a <- sf::st_as_sf(a,coords=c("lon","lat"),crs=4326)
}

## internet connection is required
glance(a,style="Esri.Satellite",border=0)


## internet connection is required
glance(a,style="opentopomap grey",border=0)


## internet connection is required
glance("Svalbard 9170",resetGrid=TRUE)
```

`global operator` *Extract certains statistics for whole image*

Description

Function from this `global.FUN` list returns required statistics *FUN* for the whole image.

Usage

```
global_mean(x, ursa = FALSE, ...)
global_median(x, ursa = FALSE, ...)
global_sd(x, ursa = FALSE, ...)
global_sum(x, ursa = FALSE, ...)
global_min(x, ursa = FALSE, ...)
global_max(x, ursa = FALSE, ...)
global_n(x, ursa = FALSE, ...)
global_nNA(x, ursa = FALSE, ...)
global_range(x, ursa = FALSE, ...)
global_quantile(x, ursa = FALSE, ...)
```

Arguments

x	Object of class ursaRaster.
ursa	Logical. The class of returned value. If FALSE then numeric vector of length one is returned (for global_range vector has length two). If TRUE then returned value is single-band raster image (two-bands image for global_range) with constant value for all cells (blank image). Default is FALSE.
...	Arguments in function global.FUN which are passed to function FUN.

Details

For any function global.FUN, if argument na.rm is not in ..., then FUN is called with forced na.rm=TRUE.
global_range\emph{list of arguments} is implemented as c(global_min(list of arguments), global_max(list of arguments)) with the same list of arguments.

Alternative method to get global statistics is function applying directly to the raster value. For example, sd(ursa_value(x,na.rm=TRUE)). This way is also appropriate for missing global functions: for example, var(ursa_value(x,na.rm=TRUE)).

Value

If ursa=FALSE then numeric.
If ursa=TRUE then object of class ursaRaster.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy(2,min=-40,max=80)
a[a<0] <- NA
print(a)
a.mean <- global_mean(a)
a.sd <- global_sd(a)
a.sum <- global_sum(a)
```

```
a.min <- global_min(a)
a.max <- global_max(a)
a.median <- global_median(a)
print(c(mean=a.mean,sd=a.sd,sum=a.sum,min=a.min,max=a.max,median=a.median))
v.max <- max(ursa_value(a),na.rm=TRUE)
print(c('global_max()'=a.max,'max(ursa_value())'=v.max,dif=a.max-v.max))
r.max <- global_max(a,ursa=TRUE)
print(r.max)
b <- c(a,'appended scalar value'=a.max)
print(b)
print(global_quantile(a))
```

`groupGeneric` *Group Generic Functions for raster image*

Description

These functions implement arithmetical and logical operations, mathematical functions for objects of class `ursaRaster` as well as group generic functions from package **base** do similar for S3 class. These are ***local*** operations in the raster algebra (map algebra).

Usage

```
## S3 method for class 'ursaRaster'
Ops(e1, e2 = NULL)

## S3 method for class 'ursaRaster'
Math(x, ...)

## S3 method for class 'ursaRaster'
Complex(z)

## S3 method for class 'ursaRaster'
Summary(..., na.rm = FALSE)
```

Arguments

`x`	`ursaRaster` object
`e1`	`ursaRaster` object
`e2`	Numeric of length 1, matrix, array, or `ursaRaster` object.
`na.rm`	Logical. If `na.rm=TRUE` then no-data values are omitted.
`z`	Any.
`...`	For group *Math* - further arguments passed to methods. See description for generic. For group *Summary* - set of arguments, which are recognized via their names (using regular expressions), position and classes.

.* Position 1. Object of class ursaRaster.

cov|cvr Position >1. Numeric between 0 and 1. If proportion of bands with no data for given location exceeds cover then output value is NA (no data). Default is 0.5-1e-3.

w Position >1. Numeric of length number of bands or NULL. Band weights for weighted mean. Default is NULL; all bands have equal weights.

name Position >1. Character of length 1. Band name for output raster. Default is ""; band name is assigned automatically.

verb(ose)* Position >1. Logical. verbose=TRUE provides some additional information on console. Default is FALSE.

Details

The groups are 'Summary', 'Ops', 'Math', and 'Complex'. See "Details" section in the S3 Generic Functions help page.

The group 'Complex' is unsupported.

The groups 'Math' and 'Summary' are implemented completely.

The group 'Ops' has some features.

- Logical operators "<", ">", "<=", ">=", "==", \"!=" return 'NA' for value FALSE and '1' for value TRUE to organize cells' masking.
- Unary operator "!" is equal to binary operator operators "!=", where the second argument is scalar value 0 (zero).

The operators of groups 'Math' and 'Ops' destroy color tables.

For group 'Summary' the realization of local operators of map algebra is possible via apply function:

```
apply(ursa_value(obj),1,function(x) {y <- sd(x)+1;y})
```

or

```
as.ursa(apply(obj,1:2,function(x) {y <- sd(x)+1;y}))
```

Value

Operators of groups 'Complex' return stop
Operators of groups 'Math', 'Ops', 'Summary' return object of class ursaRaster

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

Other S3 generic function for local operations of map algebra are mean, median.
Standard deviation (local) and certain local operations can be extracted using local_stat.

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/4))
a1 <- ursa_dummy(nband=3,min=-5*pi,max=5*pi)
print(a1)

try(print(complex1 <- Re(a1)))

print(math1 <- a2 <- round(a1))
print(math1 <- sin(a1))
print(math2 <- floor(a1))
print(math3 <- ceiling(a1))
print(math4 <- cumsum(a1)) ## does this have a sense for rasters?

print(ops1 <- a1-2*rev(a1)+mean(a1))
print(mean(ops1)) ## vanishing
a2 <- ursa_new(value=c(1,2,4),bandname=c("single","double","quadruple"))
print(a2)
print(ops2 <- a2[1]==a2[2])
print(ops3 <- a2[1]==a2[2]/2)
print(ops4 <- a1>0)
print(a1[a1>0])

print(sum1 <- sum(a1))
print(sum2 <- range(a1))
```

---

head *Extract first and last bands of raster image*

Description

Functions to extract first bands (`head`), last bands (`tail`) and first+last bands (`series`) of raster image.

Usage

```
## S3 method for class 'ursaRaster'
head(x, n = 3L, ...)

## S3 method for class 'ursaRaster'
tail(x, n = 3L, ...)

series(x, n = 3L, s=170, ...)
```

Arguments

x	Object of class `ursaRaster`
n	Positive integer. Number of extracted bands.

s	Positive numeric. Maximal size of memory in MB for extracted raster image in the assumption that class of values is numeric.
...	Not used.

Details

Function series combines consequtive calling head(x); tail(x) with checking the size of extracted part of raster image. If size exceeds specified value of the argument s, then number of extracted bands n is decreased.

Value

Object of class ursaRaster

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/8))
a <- ursa_dummy(nband=101)
print(head(a))
print(tail(a))
print(series(a,2))
print(series(a[1:5]))
```

---

hist *Histogram of raster image*

Description

Two functions for manipulation with histograms. In function hist values of ursaRaster objects are passed to generic function hist, which allows compute and optionally plot histograms. Other function, histogram, plots histogram in the graphical device png directly.

Usage

```
## S3 method for class 'ursaRaster'
hist(x, ...)

ursa_hist(obj, width = 800, height = 600, ...)
histogram(...)
```

Arguments

obj, x	Object of class ursaRaster
width	Positive integer. Width of histogram's panel.
height	Positive integer. Height of histogram's panel.
...	Other arguments, which are passed to colorize and compose_open functions.

Details

histogram is synonym of ursa_hist.

Function hist for ursaRaster object is defined as hist(ursa_value(obj),...).
In the function histogram each bin corresponds to category. The image splitting to categories is realized via colorize function. The panel of plotting is constucted using artificial coordinate system without geographical projection. The purpose of compose_open function is prepare layout for plotting raster images; in the case of histogram, the purpose of this function is prepare layout for plotting histogram

Value

Function histogram returns 0L.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

colorize is used to define histogram bins.
compose_open prepares panel for histogram plotting.
hist computes and plots histograms.

Examples

```
session_grid(NULL)
a <- pixelsize()
hist(a)
histogram(a,breaks=21)
```

---

identify *Get value and coordinates from location*

Description

Functions to extract values of raster image from given location, specified by coordinates in raster projection, by cell position or by geogpaphical coordinates. Additional utils to convert cell position and planar coordinates mutually.

Usage

```
value_xy(obj, ...)

value_ll(obj, ...)

value_cr(obj, ...)

coord_xy(obj, ...)

coord_cr(obj, ...)
```

Arguments

obj	Object of class ursaRaster.
...	the set of arguments, which are recognized via their names (using regular expressions) and classes:

Matched pattern	*Function*	*Used name*	
ind	*_*	ind	Index (positive integer) in internal value storage.
^c	*_cr	col	Integer of non-zero length. Index of column/sample Length of column and row
^r	*_cr	row	Integer of non-zero length. Index of row/line. Length of column and row indice
^x	*_xy	x	Numeric of non-zero length. X-axis coordinate in grid of obj. The length of X-
^y	*_xy	y	Numeric of non-zero length. Y-axis coordinate in grid of obj. The length of X-
^lon	value_ll	lon	Longitude. The length of longitudes and latitudes should be the same for creati
^lat	value_ll	lat	Latitude. The length of longitudes and latitudes should be the same for creating

Details

value_xy returns values for location, which is specified by planar coordinates (x, y).
value_cr returns values for location, which is specified by cell posisition (column, row) relative to upper-left corner of image .
value_ll returns values for location, which is specified by longitude and latitude (long, lat).

coord_xy transforms planar coordinates (x, y) to cell position (column, row).
coord_cr transforms cell position (column, row) to planar coordinates (x, y).

It is required to use a couple of coordinate vectors: (x, y), (c, r) or (lon, lat) of the same length. The unary argument is interpreted as index in internal value storage.

Position in column/row coordinates starts from upper-lever corner. The cell of upper-level corner has (1, 1) coordinates (in R indices starts from 1L), whereas in some GIS the same corner cell has (0, 0) coordinates.

The column names of returned matrix are character format of index in internal value storage. This index can be specify in any function as argument ind instead of coordinates (planar, geographical, cell position).

Value

For `value.*` numeric matrix of raster values. Band values for specific coordinates are by column. Set of specific coordinates are by row. `rownames` are band names, and `colnames` are index in internal value storage.

For `coord.*` numeric matrix of coordinates with a vector of couple coordinates, one coordinate per one row. `rownames` are returned coordinates, and `colnames` are index in internal value storage.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
set.seed(352)
a <- as.integer(ursa_dummy(3,min=0,max=999))
ind <- which(ursa_value(a[1])==890)
print(ind)
msk <- a[1]==890
am <- a[msk]
b <- as.data.frame(am)
b$jx <- b$x+runif(nrow(b),min=-1000,max=1000)
b$jy <- b$y+runif(nrow(b),min=-1000,max=1000)
print(b)
cr1 <- coord_xy(a,x=b$jx,y=b$jy)
cr2 <- coord_xy(a,y=b$y,x=b$x)
cr3 <- coord_xy(a,ind=ind)
print(cr1)
print(list('cr1 and cr2'=all.equal(cr1,cr2)
          ,'cr2 and cr3'=all.equal(cr2,cr3)
          ,'cr3 and cr1'=all.equal(cr3,cr1)))
xy1 <- coord_cr(a,c=cr1["c",],r=cr1["r",])
print(xy1)
print(list('in x'=identical(unname(xy1["x",]),b[,"x",drop=TRUE])
          ,'in y'=identical(unname(xy1["y",]),b[,"y",drop=TRUE])))
val1 <- value_xy(a,x=b$jx,y=b$jy)
val2 <- value_xy(a,x=b$x,y=b$y)
val3 <- value_cr(a,ind=ind)
val4 <- value_cr(a,c=cr1["c",],r=cr1["r",])
print(val1)
print(list('val1 and val2'=all.equal(val1,val2)
       ,'val2 and val3'=all.equal(val2,val3)
       ,'val3 and val4'=all.equal(val3,val4)
       ,'val4 and val1'=all.equal(val4,val1)))
ps <- pixelsize()
v <- value_ll(ps,lon=180,lat=70)
print(c('True scale'=v/with(ursa_grid(ps),1e-6*resx*resy)))
```

ignorevalue *Extract and assign 'nodata' value of raster images.*

Description

Ignored values (*aka* 'nodata') are implemented via NA values, and are optional for raster images in memory. However, to avoid ambiguity for data storage, it is desirable to specify ignored value. "ENVI .hdr Labelled Raster" supports 'nodata' by means of "data ignore value" field in the header file.

Usage

```
ignorevalue(obj)
ursa_nodata(obj)

ignorevalue(obj) <- value
ursa_nodata(obj) <- value
```

Arguments

obj	ursaRaster object.
value	Integer of numeric of length one. Ignored ('nodata') value.

Details

ursa_nodata is synonym to ignorevalue for both *Extract* and *Replace* methods.

The 'nodata' value of raster image obj is specified in the item objconnodata.

If values of raster image are in memory then *replace* function ignorevalue<- also changes 'nodata' values to NA values.

Value

Extract function ignorevalue returns value of connodata item of ursaRaster object.

Replace function ignorevalue<- returns ursaRaster with modified connodata item.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
a <- round(ursa_dummy(nband=1,min=0.500001,max=4.499999))
print(a)
print(as.table(a))
print(ignorevalue(a))
ignorevalue(a) <- NA
```

```
print(as.table(a))
print(ignorevalue(a))
ignorevalue(a) <- 4
print(as.table(a))
print(ignorevalue(a))
print(a)
```

`is.na` *'No data' values for raster images.*

Description

The "Extract" function `is.na` creates mask for each band. In this mask value `1L` corresponds to `NA` value in the source image, and value `NA` corresponds non-missing values in the source image. The "Replacement" function `is.na<-` assigns numerical value for cells with 'no data' value.

Usage

```
## S3 method for class 'ursaRaster'
is.na(x)

## S3 method for class 'ursaRaster'
is.infinite(x)

## S3 method for class 'ursaRaster'
is.nan(x)

## S3 replacement method for class 'ursaRaster'
is.na(x) <- value
```

Arguments

`x`	Object of class `ursaRaster`
`value`	Numeric.

Details

These functions are corresponded to **local** operators of map algebra.

Value

"Extract" functions `is.na`, `is.infinite`, `is.nan` return object of class `ursaRaster`.

"Replacement" function `is.na<-` modifies object of class `ursaRaster`.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/4))
a <- ursa_dummy(nband=2,min=0,max=100)
print(a)
print(is.na(a))
a2 <- ursa_new(nband=2)
print(a2)
print(is.na(a2))
a3 <- a
a3[a3<30 | a3>70] <- NA
print(a3)
print(is.na(a3))
is.na(a3) <- 200
print(a3)
```

---

legend_align *Align caption position for legend*

Description

When multiple panels on the same axis, the different order of values or different units of values may provoke different shifting of values and caption from panels. `legend_align` repairs it by the taking names of classes of the required rasters. The function output is for argument `aling` of `legend_colorbar`.

Usage

```
legend_align(obj)
```

Arguments

`obj`	Object of class `ursaColorTable`, or object of class `ursaRaster`, or list of `ursaColorTable` or `ursaRaster` objects.

Details

The function is defined as:

```
c(unlist(sapply(obj,function(x) names(ursa_colortable(x)))))
```

Value

Character vector.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

legend_colorbar

Examples

```
session_grid(NULL)
a <- ursa_dummy(5,mul=1/4,min=-150,max=200)
a[1] <- a[1]*100
a[2] <- -a[2]*10
a[3] <- a[3]/10
a[4] <- a[4]/1000
b <- lapply(a,colorize)
la.top <- legend_align(b[c(1,2)])
la.left <- legend_align(c(b[[1]],b[[3]]))
la.bottom <- legend_align(b[c(3,4)])
la.right <- legend_align(b[c(2,4)])
leg <- vector("list",12)
leg[[1]] <- list("top",2)
leg[[2]] <- list("top",3)
leg[[3]] <- list("bottom",1)
leg[[4]] <- list("bottom",2)
leg[[5]] <- list(2,"left")
leg[[6]] <- list(1,"right")
leg[[7]] <- list(3,"left")
leg[[8]] <- list(2,"right")
leg[[9]] <- list("top",1)
leg[[10]] <- list("bottom",3)
leg[[11]] <- list(1,"left")
leg[[12]] <- list(3,"right")
cl <- compose_design(layout=c(3,3),legend=leg,byrow=TRUE,skip=5)
print(cl)
compose_open(cl)
ct <- compose_panel(b[c(5,1,2,1,4,3,4,5)],decor=FALSE)
L <- 2
Tr <- 2
legend_colorbar(b[1],trim=Tr,las=L,align=la.top,units="top aligned --->")
legend_colorbar(b[2],trim=Tr,las=L,align=la.top,units="<--- top aligned")
legend_colorbar(b[3],trim=Tr,las=L,align=la.bottom,units="bottom aligned --->")
legend_colorbar(b[4],trim=Tr,las=L,align=la.bottom,units="<--- bottom aligned")
legend_colorbar(b[1],trim=Tr,las=L,align=la.left,units="<--- left aligned")
legend_colorbar(b[2],trim=Tr,las=L,align=la.right,units="<--- right aligned")
legend_colorbar(b[3],trim=Tr,las=L,align=la.left,units="left aligned --->")
legend_colorbar(b[4],trim=Tr,las=L,align=la.right,units="right aligned --->")
legend_colorbar(b[5],trim=Tr,las=L,units=" *** not aligned ***")
legend_colorbar(b[5],trim=Tr,las=L,units=" *** not aligned ***")
legend_colorbar(b[5],trim=Tr,las=L,units=" *** not aligned ***")
legend_colorbar(b[5],trim=Tr,las=L,units=" *** not aligned ***")
compose_close()
```

`legend_colorbar` *Plot colorbar*

Description

Functions draw single color bar outside of maps panels. `legend_colorbar` (without prefix dot) is a wrapper for non-public `.legend_colorbar` (with prefix dot)

Usage

```
legend_colorbar(...)

## non-public
.legend_colorbar(ct, units = "", labels = NA, align = NULL, shift = 1, cex = 1,
                 adj = NA, las = 1, forceLabel = FALSE, lomar = 0, himar = 0,
                 turn = FALSE, useRaster = NA, trim = 0L, abbrev = 24L,
                 opacity = NA, verbose = FALSE)
```

Arguments

`...` Set of arguments, which are recognized via their names (using regular expressions) and classes. Passed to non-public `.legend_colorbar`, excepting argument `colorbar`:

Matched pattern (`legend_colorbar`)	*Argument* (`.legend_colorbar`)	*Description*
`colorbar`		Prefix for indirect use (e.g., in `display`). Separated
`(ct)*`	`ct`	*See below*.
`unit(s)*`	`units`	*See below*.
`labels`	`labels`	*See below*.
`align`	`align`	*See below*.
`shift`	`shift`	*See below*.
`cex`	`cex`	*See below*.
`adj`	`adj`	*See below*.
`las`	`las`	*See below*.
`forceLabel`	`forceLabel`	*See below*.
`lomar`	`lomar`	*See below*.
`himar`	`himar`	*See below*.
`turn`	`turn`	*See below*.
`useRaster`	`useRaster`	*See below*.
`trim`	`trim`	*See below*.
`abbrev`	`abbrev`	*See below*.
`opacity`	`opacity`	*See below*.
`verb(ose)*`	`verbose`	*See below*.

`ct` `ursaRaster` object with color table or object of class `ursaColorTable`. First argument in `legend_colorbar`; name can be omitted.

`units` Argument of class `character` or `expression` with matching name `"unit(s)*"` in `legend_colorbar`. Text, which is used as a caption for color bars. If `character` then caption is displayed in bold. Default is `""`: no caption.

`labels` Argument of class `integer` or `character` with matching name `"labels"` in `legend_colorbar`. If `labels` is vector of length 1, then it is number of labels at the color bar, else vector of specified values. Default is `NA`: it means 11 labels for numerical values and 31 labels for categorical values, but this number can be reduced for perpendicular orientation to the axes to prevent label overlapping.

`align` Argument of class `numeric` with matching name `"align"` in `legend_colorbar`. The indent for right alignment of labels. May be useful, if two or more color bars are located on the same side, but with different units and order of values. Can be specified by the string of maximal length or via `legend_align`. Default is `NULL`: right alignment of each color bar is independent.

`shift` Argument of class `numeric` with matching name `"shift"` in `legend_colorbar`. Multiplier for manual correction of labels alignment in the case when automatical alignment is poor. Default is `1`: no changes. If `shift<1` then labels are shifted to the left. If `shift>1` then labels are shifted to the right.

`cex` Argument of class `numeric` with matching name `"cex"` in `legend_colorbar`. A numerical value giving the amount by which labels should be magnified relative to the default. Default is `1`.

`adj` Argument of class `numeric` with matching name `"adj"` in `legend_colorbar`. Adjustment for labels. For labels parallel to the axes, `adj=0` means left or bottom alignment, and `adj=1` means right or top alignment. Default is `NA`: for labels parallel to the axes `adj=0.5`, for labels perpendicular to the axis `adj=1` for numeric and `adj=0` for character.

`las` Argument of values `0, 1, 2, 3` with matching name `"adj"` in `legend_colorbar`. The correspondence between directions of axis and labels. The same definition as for `par(las=)`. Default is `1L`.

`forceLabel` Argument of class `logical` with matching name `"forceLabel"` in `legend_colorbar`. If `TRUE` then all labels are plotted regardless their possible overlapping.

`lomar` Argument of class `numeric`, non-negative, with matching name `"lomar"` in `legend_colorbar`.Relative shifting of the lower (left or bottom) position of colorbar. Default is `0`: the lower position is corresponded to the limit of panel(s). Positive value decreases length of colorbar.

`himar` Argument of class `numeric`, non-negative, with matching name `"himar"` in `legend_colorbar`. Relative shifting of the higher (right or bottom) position of colorbar. Default is `0`: the higher position is corresponded to the limit of panel(s). Positive value decreases length of colorbar.

`turn` Argument of class `logical` with matching name `"turn"` in `legend_colorbar`. Default is `FALSE`: lower value is on left or bottom, higher value is on right or top. If `turn=TRUE`, then opposite order.

`useRaster` Argument of class `logical` with matching name `"useRaster"` in `legend_colorbar`. Passed as argument `useRaster` to function `image`. Default is `NA`, which is interpreted as `TRUE` for "cairo" graphical device and as `FALSE` for "windows" graphical device (see description of argument `type` in `png`).

trim	Argument of values 0L, 1L, 2L with matching name "trim" in legend_colorbar. Determines behaviour for plotting marginal labels. If 0L, then marginal labels are displayed as is. If 1L, then marginal labels are shifted inside of color bar to prevent their outcrop to the panel(s) limits. If 2L then outctopped labels are not displayed.
abbrev	Argument of class integer or logical with matching name "abbrev" in legend_colorbar. TRUE is interpreted as default value. FALSE is interpreted as 0L. If positive, then labels are abbreviated, and this argument is passed as argument minlength to function abbreviate: abbreviate(label, minlength=abbrev, strict=TRUE). If abbreviation is failed (e.g., non-ASCII symbols), the subset is applied.
opacity	Argument of class integer or logical with matching name "abbrev" in legend_colorbar. Responses for shading of color bar. If FALSE or 0, then no shading. If TRUE or 1, then shading is forced. Default is NA; if semi-transparence is detected, then shading is applied.
verbose	Argument of class logical with matching name "verb(ose)*" in legend_colorbar. Value TRUE may provide some additional information on console. Default is FALSE.

Details

If units are expression, then possible way for formatting is:

```
units=as.expression(substitute(bold(degree*C)))
```

Value

NULL

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
display(ursa_dummy(1),units="Required 99 labels; displayed less"
        ,colorbar.labels=99,las=3,gridline.trim=FALSE,colorbar.trim=1L)
cname <- c("Apple","Orange","Cherry","Blueberry","Strawberry","Currant")
a <- ursa_dummy(4)
b <- list(colorize(a[1],value=seq(50,200,length=length(cname))
                  ,name=cname)#,stretch="category")
         ,colorize(a[2]*10,ramp=FALSE),colorize(a[3]*100),colorize(a[4]/10))
la <- legend_align(b[3:4])
leg <- vector("list",10)
leg[[1]] <- list(1,"left")
leg[[2]] <- list(1,"right")
for (i in seq(4)) {
   leg[[i+2]] <- list("top",i)
   leg[[i+6]] <- list("bottom",i)
}
```

```
compose_open(layout=c(1,4),legend=leg,scale=NA,dev=FALSE) # use 'dev=TRUE' to check layout
compose_panel(b)
legend_colorbar(b[[1]],lomar=20,himar=0) ## "left"
legend_colorbar(b[[4]],labels=c(6,7.5,12,15,20)
               ,units="Manual set of labels") ## "right"
legend_colorbar(b[[1]],las=2,adj=0.5,turn=TRUE,lomar=6,himar=6
               ,units="Central adjustment; inverse order") ## ("top",1)
legend_colorbar(b[[2]],cex=0.9
               ,units="Horizontal labels can be overlapped") ## ("top",2)
legend_colorbar(b[[3]],las=3,align=la
               ,units="Increased width, but aligned -->") ## ("top",3)
legend_colorbar(b[[4]],las=3,align=la,labels=3
               ,units="<-- Reduced width, but aligned") ## ("top",4)
legend_colorbar(b[[1]],las=2,adj=0,shift=0.9,turn=FALSE,lomar=2,himar=10
               ,units="Left adjustement. Non-optimal; shifted") ## ("bottom",1)
legend_colorbar(b[[2]],las=3,adj=0
               ,units="But right adj. is default for numeric") ## ("bottom",2)
legend_colorbar(b[[3]],labels=99,las=3,trim=2L
               ,units="Required 99 labels, but displayed less") ## ("bottom",3)
legend_colorbar('Caption from named item'=b[[4]],labels=99) ## ("bottom",4)
compose_close()
```

`legend_mtext` *Write marginal text*

Description

Functions write text outside of maps panels. `legend_mtext` (without prefix dot) is a wrapper for non-public `.legend_mtext` (with prefix dot).

Usage

```
legend_mtext(...)

## non-public
.legend_mtext(text = "Annotation", cex = 1)
```

Arguments

`...`	Set of arguments, which are recognized via their names (using regular expressions) and classes. Passed to non-public `.legend_mtext`, excepting argument `mtext`: `mtext` Prefix for indirect use (e.g., in `compose_legend`). Separated by a dot `"."`, e.g., `mtext.cex=0.85`.

Matched pattern (`legend_colorbar`)	*Argument* (`.legend_colorbar`)	*Description*
`mtext`		Prefix for indirect use (e.g., in `compose_legend`). S
`text`	`text`	*See below*.

cex	cex	*See below*.

text — Argument of class character or expression with matching name "text" (or without name) in legend_mtext. Text, which is displayed. If character then text is displayed in bold. Default is "Title/subtitle".

cex — Argument of class numeric with matching name "cex" in legend_mtext. A numerical value giving the amount by which labels should be magnified relative to the default. Default is 1.

Details

If text is expression, then possible way for formatting is:

```
text=as.expression(substitute(bold(italic("Omega powered by alpha is ",Omega^alpha))))
```

Value

Returned value of function mtext from package **graphics**.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

compose_legend
legend_colorbar

Examples

```
session_grid(NULL)
a <- ursa_dummy(1,min=-10,max=+30)
compose_open(legend=list("right","top","bottom","left"))
panel_new()
ct <- panel_raster(a)
legend_colorbar(ct)#,units=as.expression(substitute(bold(degree*C))))
legend_mtext("Characters are in bold")
legend_mtext(as.expression(substitute(italic(
            paste("Units can be interpreted as",~degree*C)))),cex=0.7)
legend_mtext(text=as.expression(substitute(italic(paste("Omega powered by alpha is"
                                                        ,~~Omega^alpha)))))
compose_close(execute=!FALSE)
```

local_group *Create single-band raster using statistics of multi-bands raster.*

Description

Local operations (mean value, sum of values, median, minimum, maximum) of map algebra for multi-bands ursaRaster object.

Usage

```
local_mean(x, cover = 0.5 - 1e-3, weight = NULL, verbose = FALSE, bandname = "mean")
local_sum(x, cover = 0.5 - 1e-3, weight = NULL, verbose = FALSE, bandname = "sum")
local_median(x, cover = 0.5 - 1e-3, verbose = FALSE)
local_min(x, cover = 0.5 - 1e-3, verbose = FALSE)
local_max(x, cover = 0.5 - 1e-3, verbose = FALSE)
local_sd(x, cover = 0.5 - 1e-3, verbose = FALSE)
local_var(x, cover = 0.5 - 1e-3, verbose = FALSE)
local_quantile(x, probs = seq(0, 1, 0.25), type = 7, cover = 0.5 - 1e-3, verbose = FALSE)

## S3 method for class 'ursaRaster'
mean(x, ...)

## S3 method for class 'ursaRaster'
median(x, ...)

## S3 method for class 'ursaRaster'
quantile(x, ...)

# non public
.average(x, cover = 0.5 - 1e-3, weight = NULL, sum = FALSE, verbose = FALSE)
```

Arguments

x	ursaRaster object. In function local_mean and local_sum it is allowed to specify array with 3 dimensions (col, row, band) or (row, col, band)
cover	Numeric. 0<=cover<=1 or >1. Quota for NA values in the location for all bands. Quota exceeding leads to recording NA value in the created map. If code>1 then number of bands. If 0<=cover<=1 then proportion cover to number of bands.
weight	Positive numeric of length equal to number of bands. For local_mean and local_sum only. If specified, then weighted mean or sum are applied. The prior normalization is not required.
sum	Logical. For .average only. If sum=TRUE then fuction returns sum of values else mean value.
probs	Numeric. For local_quantile only. Argument probs, which is passed as argument probs to generic function quantile().

type	Numeric. For local_quantile only. Argument type, which is passed as argument probs to generic function quantile().
verbose	Logical. If verbose=TRUE then some output appears in console. Used for debug and benchark.
bandname	Character. Band name for created single-band image.
...	Function mean - arguments, which are passed to local_mean(). Function median - arguments, which are passed to local_median(). Function quantile - arguments, which are passed to local_quantile().

Details

If for valid output cell value it is required to have at least m values not marked as NA, specify quota as cover=m/nband(x).

local_mean and local_sum are wrapper to non-public function .average.

Generic functions mean, median, sd for ursaRaster class are implemented via local_mean, local_median, local_sd, respectively.

Value

Double-band ursaRaster object for local_range().
Multi-band ursaRaster object for local_quantile().
Otherwise, single-band ursaRaster object.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

If bands are interpreted as time series, apply local_stat

Mean value for image brick global_mean

Mean value for each band band_mean

Examples

```
session_grid(NULL)
b <- ursa_dummy(nband=7,min=0,max=100,mul=1/16)
b[b<40] <- NA
print(b)
res <- c('mean'=mean(b),'local_mean'=local_mean(b)
        ,'sum0'=local_sum(b,cover=0),'sum1'=local_sum(b,cover=1))
print(res)

display(b)
display(res)
```

local_stat *Bundle of statistics, which is applied to each cell of multi-band image.*

Description

If bands of ursaRaster object are interpreted as observations in time, then local_stat returns some parameters for time-series analysis. This is a **local** operation of map algebra.

Usage

```
local_stat(obj, time = NULL, cover = 1e-06, smooth = FALSE, verbose = FALSE)
```

Arguments

obj	Object of class ursaRaster
time	Numeric or NULL. If NULL then regression parameters are for regular time-series using position of band in the brick (or, time=seq(obj)). If numeric, then length of time should be equal to number of bands of obj, and time is used to set irregularity for time-series.
cover	Numeric. 0<=cover<=1 or >1. Quota for NA values in the location for all bands. Quota exceeding leads to recording NA value in the cell of created band. If code>1 then number of bands. If 0<=cover<=1 then proportion cover to number of bands. Default is 1e-6.
smooth	Logical. If TRUE then median focal smoothing is applying to created 'slope' band; it is more suitable for visualization. Default is FALSE.
verbose	Logical. Value TRUE provides some additional information on console. Default is FALSE.

Value

Object of class ursaRaster with bands:

mean	Mean value in each cell across all bands of source raster.
sd	Standard deviation in each cell across all bands of source raster. Denominator is n.
sum	Sum value in each cell across all bands of source raster.
min	Minimal value in each cell across all bands of source raster.
max	Maximal value in each cell across all bands of source raster.
n	Number of non-NA values in each cell across all bands of source raster (number of observations).
slope	Slope value in each cell across all bands of source raster.
slopeS	Significance of slope value taken with a sign of slope.
RSS	Resisual sum of squares.
ESS	Explained sum of squares.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

Local statistics of map algebra, Group generics for objects of class ursaRaster.

Examples

```
session_grid(NULL)
set.seed(353)
session_grid(regrid(mul=1/8))
a <- ursa_dummy(nband=15)
a[a<60] <- NA
cvr <- 12
b <- local_stat(a,cover=cvr)
print(b)
c.mean <- c('<bundle> mean'=b["mean"]
           ,'local_mean'=local_mean(a,cover=cvr)
           ,'<generic> mean'=mean(a,cover=cvr))
c.max <- c('<bundle> max'=b["max"]
          ,'local_max'=local_max(a,cover=cvr)
          ,'<generic> max'=max(a,cover=cvr))
print(c.mean)
print(c.max)
cmp <- c(mean=b["mean"]-local_mean(a,cover=cvr)
        ,sd=b["sd"]-local_sd(a,cover=cvr))
print(round(cmp,12))
d <- as.list(b)
d[["slopeS"]] <- colorize(d[["slopeS"]],stretch="signif")
display(d,blank.density=20,blank.angle=c(-45,45))
```

---

na.omit *Drop bands which don't have data.*

Description

The bands with band_blank images, are omitted.

Usage

```
## S3 method for class 'ursaRaster'
na.omit(object, ...)
```

Arguments

object	Object of class ursaRaster.
...	Ignored. For consistence with definition of generic function.

Value

Object of class `ursaRaster`, which has no bands without any data.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

band_blank

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/4))
a <- ursa_new(value=1:3)
print(a)
a[2] <- NA
print(a)
a2 <- na.omit(a)
print(a2)
```

---

nband *Get number of bands of raster image.*

Description

`nband` (`length`) returns number of bands (*layers*, if appropriate in terminology) of `ursaRaster` object.

Usage

```
nband(x)

## S3 method for class 'ursaRaster'
length(x)
```

Arguments

`x`	Object of class `ursaRaster`

Details

`length` for `ursaRaster` object is a synonym for `nband`.

Value

Positive integer of length 1.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

bandname (names for ursaRaster object).

Examples

```
session_grid(NULL)
a1 <- pixelsize()
print(a1)
print(nband(a1))
a2 <- c("Band 1"=a1,Band2=a1/2,sqrt=sqrt(a1),NA)
print(a2)
print(nband(a2))
```

---

open_envi *open_envi file*

Description

open_envi creates object of ursaRaster class, reads ENVI header file and prepares connections for ENVI binary file

Usage

```
open_envi(fname, resetGrid = FALSE, headerOnly = FALSE, decompress = !headerOnly,
          cache = 0L, ...)
```

Arguments

fname	Filename; full-name or short-name
resetGrid	Logical. If TRUE then existing base grid (from session_grid) will be overwritten. Otherwise the spatial subsetting will be attempted.
headerOnly	Logical. If TRUE then only reading of ENVI header file without creating connection to binary data; there is no necessary to decompress packed binary in this case. Default is FALSE.
decompress	If ENVI binary file is compressed and you have not to use ENVI values then put decompress=FALSE to avoid useless operation
cache	Integer. Using cache for compressed files. If 0L then cache is not used. If 1L, then cache is used. Any value, which is differed from 0L and 1L, resets cache. Default is 0L.
...	If input file does not exists then these additional arguments will be passed to create_envi function.

Details

open_envi try to find ENVI files (binary and header) and open them. If unsuccessful then function passes ...-arguments to create_envi function

Value

Returns object of class ursaRaster. Values from ENVI binary are not in memory yet.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

close, create_envi

Examples

```
session_grid(NULL)
a <- pixelsize()
write_envi(a,"example")
a <- open_envi("example")
dir(pattern="^example.*")
ursa_info(a)
close(a)
rm(a)
envi_remove("example")

## additional arguments are enough to create new ENVI file
dir(pattern="^example.*")
a <- open_envi("example",layername=paste0("test",1:3))
ursa_info(a)
dir(pattern="^example.*")
close(a)
envi_remove("example")
```

---

open_gdal *Open GDAL file*

Description

open_gdal creates object of ursaRaster class, and prepares connections for data reading.

Usage

```
open_gdal(fname, engine=c("native", "sf", "gdalraster", "vapour"), verbose = FALSE)

ursa_open(fname, verbose = FALSE)
```

Arguments

fname	Character. Filename; full-name or short-name.
engine	Character. Functionality of which package is used for reading data. This is experimental list, which future depends on evolution of reviewed packages and their availability for partial reading of multiband rasters.
verbose	Logical. verbose=TRUE provides some additional information on console. Default is FALSE.

Details

ursa_open is a synonym to open_gdal. *Generally, both function names are abridged version of* ursa_open_dgal.

open_gdal doesn't read data. Data can be read later using *Extract* operator [.

If argument fname is ENVI .hdr Labelled Raster then either open_gdal or open_envi can be used. The former provides external implementation for data reading via GDAL in **rgdal** package.

Value

Returns object of class ursaRaster. Values are not in memory.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

close, open_envi, read_gdal.

Examples

```
session_grid(NULL)
# fname1 <- system.file("pictures/cea.tif",package="rgdal")
fname1 <- system.file("tif/geomatrix.tif",package="sf")
message(fname1)
a1 <- open_gdal(fname1)
print(a1)
print(a1[])
close(a1)
# fname2 <- system.file("pictures/test_envi_class.envi",package="rgdal")
fname2 <- tempfile(fileext=".")
a <- ursa_dummy(1,resetGrid=TRUE)
b <- colorize(a[a>91],stretch="equal",name=format(Sys.Date()+seq(0,6),"%A %d"))
write_envi(b,fname2)
message(fname2)
b1 <- open_gdal(fname2)
b2 <- open_envi(fname2)
print(b1)
print(b2)
print(c('The same grid?'=identical(ursa_grid(b1),ursa_grid(b2))
```

```
       ,'The same data?'=identical(ursa_value(b1[]),ursa_value(b2[])))
close(b1,b2)
envi_remove(fname2)
```

---

panel_annotation *Add label or annotation to the image panel.*

Description

panel_annotation puts an annotation (text label) on the panel with raster image without anchors to any layer. Can be used as captions to image panels.

Usage

```
panel_annotation(...)

# non-public
.panel_annotation(label = expression(), position = "bottomright",
                  lon = NA, lat = NA, x = NA, y = NA, cex = 1.0, adjust = 0.5,
                fg = "#000000", bg = "#FFFFFF1F", buffer = 1, fill = "#FFFFFF7F",
                  font = par("family"), vertical = FALSE, alpha = 1,
                  interpolate = FALSE, resample = FALSE, verbose = FALSE, ...)
```

Arguments

...	Set of arguments, which are recognized via their names (using regular expressions) and classes:

Matched pattern (panel_annotation)	*Argument* (.panel_annotation)	*Description*
((caption|ann(otation)*)		Logical or integer. Responsible for should annota
(label|text)	label	*See below*.
pos(ition)*	pos	*See below*.
lon(gitude)*	lon	*See below*.
lat(itude)*	lat	*See below*.
x$	x	*See below*.
y$	y	*See below*.
cex	cex	*See below*.
adj(ust)*	adjust	*See below*.
fg	fg	*See below*.
bg	bg	*See below*.
buf(fer)*	buffer	*See below*.
fill	fill	*See below*.
font	font	*See below*.
vert(ical)*	vertical	*See below*.
(alpha|transp(aren(cy)*)*)	alpha	*See below*.
interp(olate)*	interpolate	*See below*.
resample	resample	*See below*.

verb(ose)*	verbose	*See below*.

label	Character, expression, or objects of classes array or matrix. Text, symbols or logo for displaying on image panel. Multi-row characters are allowed with delimiter "\n". Default is expression().
position	Character keyword or numeric of length 2 in the interval [0,1]. Defines the location of scale bar. If character, then one of the "bottomleft", "bottomright", "topleft", "topright", "left", "right", "bottom", "top", or "center". If numeric then relative position on panel is defined using shift on horizontal and vertical axes from origin in the bottom-left corner. Default is "bottomright".
lon	Numeric. Longitude for center of annotation's position. Default is NA.
lat	Numeric. Latitude for center of annotation's position. Default is NA.
x	Numeric. The horizontal coordinate of the annotation's position in the units of image grid. Default is NA.
y	Numeric. The vertical coordinate of the annotation's position in the units of image grid. Default is NA.
cex	Positive numeric. The relative font size for annotation's label. Default is 1. See description of argument cex in text function.
adjust	One or two values in [0, 1]. Specifies the horizontal (and optionally vertical) adjustment of the labels. See description of argument adj in text function.
fg	Character. Color name or code for label (texts and symbols). Default is "#000000" (black).
bg	Character. Color name or code for thin buffer around label's elements. Default is NA, which is interpreted as "transparent" for *captions* and as "#FFFFFF1F" for *annotations*.
buffer	Numeric. The relative width of buffer around label's elements. Default is 1.
fill	Character. Color name or code for circumscribed rectangle around labels. Default is NA, which is interpreted as "#FFFFFF7F" for *captions* and as "transparent" for *annotations*.
font	Character. Font family. Default is getOption("ursaPngFamily"), which is specified by argument font (or family) in compose_open().
vertical	Logical or numeric. Vertical or inclined orientation of label. If FALSE, then horizontal labeling. If numeric then vertical defines text direction in degrees. Limitation: value 1 is interpreted as TRUE. Default is FALSE, which means horizontal text direction.
interpolate	Logical. Passed as argument interpolate to function rasterImage for logo annotation.
resample	Logical or numeric. Passed as argument resample to function regrid for logo annotation. Default is FALSE. If TRUE , then resized logo is drawn smoothly.
alpha	Numeric or character. Level of transparency for logos. If numeric, the either 0 <= alpha <= 1 or 0 <= alpha <= 255. If character, then one byte of hexadecimal value "00" <= alpha <= "FF". Default is 1.
verbose	Logical. Value TRUE may provide some additional information on console. Default is FALSE.

Details

This function is based on function text with adding some decoration elements. For low-level plotting use layout.text function, which is equal to function text with additional control of image panels.

Since the most of character keywords of `position` have relation to the boundary of image panel, such annotation is assigned as a *caption* for image panel. Default decoration is shadowed background rectangle, which is implemented by function rect.

If location is defined by two-dimensional vector (either relative position inside of image boundaries (`pos` is numeric of length two), or pair `lon`, `lat`, or pair `x`, `y`), then such labeling is assigned as an *annotation*. Default decoration is thin buffer around symbols. The implementaion is via application of function function text for small diplacements around original position.

The priority of arguments (from higher to lower): 1) pair `lon`, `lat`, 2) pair `x`, `y`, 3) two-dimensional numeric of `pos`, 4) character keyword of `pos`. However, the default annotation is interpreted as a caption.

Value

This function returns `NULL` value.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
## exam no.1 -- direct use
compose_open(layout=c(2,3),legend=NULL,device="cairo")
for (i in seq(6)) {
   panel_new()
   panel_annotation(label=LETTERS,cex=1.5)
   panel_annotation(pos=c(0.7,0.2)
                    ,label=paste("panel",paste("no.",i),sep="\n"))
   if (i==1)
      panel_annotation(pos="center")
}
compose_close()

## exam no.2 -- indirect use
display(pixelsize(),scale=2
       ,ann.label="FJL",ann.lon=52,ann.lat=80,ann.buffer=1
       ,ann.bg="#8F6FFF2F",ann.fill="#FFFF7F9F",ann.font="courier")
```

`panel_coastline` *Add coastline to the image panel.*

Description

panel_coastline puts a coastline to the active panel of layout with optional land shadowing. The package provides data for coastline.

Usage

```
compose_coastline(...)

panel_coastline(...)

update_coastline(merge = TRUE)

# not public
.compose_coastline(obj = NULL, panel = 0, col = NA, fill = "transparent",
                   detail = NA, density = NA, angle = NA, land = FALSE,
                   lwd = 0.5, lty = 1, fail180 = NA, verbose = FALSE)

# not public
.panel_coastline(obj, verbose = FALSE)
```

Arguments

...	Set of arguments, which are recognized via their names (using regular expressions) and classes:

Matched pattern	*Used name*	*Description*
coast(line)*		Logical or integer. Responsible for should coastline be displayed or not. If integer, the indica
(obj)*	obj	*See below.*
panel	panel	*See below.*
fill	fill	*See below.*
detail	detail	*See below.*
density	density	*See below.*
angle	angle	*See below.*
land	land	*See below.*
lwd	lwd	*See below.*
lty	lty	*See below.*
fail180	fail180	*See below.*
verb(ose)*	verbose	*See below.*

obj	Objects of the one of the classes Spatial, sfc, ursaCoastLine. The last one is internal structure, which is returned by function .compose_coastline.
panel	Integer vector. Panel for which coastline will be displayed. 0L means that coastline will bw displayed for all panels. Default is 0L.
col	Character. Color code/name for coastline. Default is "grey60".
fill	Character. Color code/name for land masking/shadowing. Default is "transapent".

detail	Character keyword. The categorical spatial resolution for coastline. Valid values are "l" (low), "m" (medium), "h" (high), "f" (full). If value is NA, then coasline resolution is selected internally. Default is NA.
density	Numeric. The density of shading lines for land masking/shadowing. If NA then no shading lines are drawn. Default is NA. See density in polygon.
angle	Numeric. The slope of shading lines, given as an angle in degrees (counter-clockwise). If NA then no shading lines are drawn. Default is NA. See angle in polygon.
land	Logical. If TRUE then map's accent is to land, and ocean is masked/shadowed. If FALSE then map's accent is to ocean, and land is masked/shadowed. Default is FALSE.
lwd	Positive numeric. Width of coastline. Default is 1. See lwd in par.
lty	Positive integer. Type (pattern) of coastline. Default is 1L (solid). See lty in par.
fail180	Logical. Patch for correct plotof polygons crossing 180 degree longitude. NA means than decision is taken intuitively. TRUE forces to implement crossing og 180 degree longitude. FALSE forces to not implement crossing og 180 degree longitude. Default is NA.
verbose	Logical. Value TRUE may provide some additional information on console. Default is FALSE.
merge	Logical. Ingored.

Details

compose_coastline forms an obect of class ursaCoastLine. panel_coastline displays object of class ursaCoastLine. It is expected higher performance for multi-panel plotting.

If obj is NULL, then internal data is used. This data is based on simplified polygons of OpenStreetMap-derived data. Source data is licensed under the Open Data Commons Open Database License (ODbL). The crossing longitude 180 degrees polygons are merged. Removing of small polygons and simplifying of polygons geometry is applied for three levels of details ("l" - low, "i" - interim, "h" - high). For the full ("f") level of details data simplification is not applied.

Coastline data are taken from directory, which is specified by getOption("ursaRequisite") with default value system.file("requisite",package="ursa"). Package contains data of "l" (low) details level in the file system.file("requisite/coast-l.rds",package="ursa"). Data of higher levels can be added using update_coastline() function. It is required to specify user's requisite path using options(ursaRequisite=path/to/user/files) before loading **ursa**, e.g. in the user's ~/.Rprofile file. Otherwise, there is a chance that data can not be updated due to 'permission deny' of the system directories. Package **sf** and some it's suggestions are required for data update.

If detail=NA then the spatial resolution is selected using CRS boundary and resolution using intuitive approach. If package's database cannot supply required details, then lower resolution is used.

Source coastline data in EPSG:4326 are transformed to CRS projection, extracted using session_grid function. Coastlines with optional filling of either land or ocean area is interpreted as polygons. If filling is solid (there is no transparency or shading lines (numerical values of arguments density and angle), then coastline plotting is imlemented via polypath function, otherwise polygon function.

Value

`panel_coastline` returns `NULL`

`compose_coastline` returns of object of class `ursaCoastLine`. It is a list:

`coast_xy`	Two-column matix of coordinates in the sessional projection. The polygons are separated by `c(NA,NA)` rows.
`panel`	Integer. Panel for coastline displaying. If `0L`, then coastline is displayed on each panel.
`col`	See description of argument `col`.
`fill`	See description of argument `fill`.
`shadow`	If filling is semi-transparent, then it is "alpha" of filling color (argument `fill`).
`land`	See description of argument `land`.
`density`	See description of argument `density`.
`angle`	See description of argument `angle`.
`lwd`	See description of argument `lwd`.
`lty`	See description of argument `lty`.

License

Coastal data (land polygons) is distributed under ODbL.

Note

In the versions <=3.7-19 package **ursa** contained land polygons based on union of "GSHHS_l_L1.shp" and "GSHHS_l_L5.shp" data from Self-consistent Hierarchical High-resolution Geography Database (GSHHG), Version 2.3.3 (01 November 2014), distributed under the Lesser GNU Public License, Version 3 (29 June 2007).

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a <- pixelsize()
p1 <- colorize(a[a>500],ramp=FALSE,interval=TRUE)
p2 <- colorize(a,ramp=FALSE,pal=colorRampPalette(c("grey40","grey100"))
              ,verbose=!TRUE,interval=TRUE)
compose_open(layout=c(2,2),legend=list(list(1,"right"),list(2,"left")))
for (i in 1:4) {
   panel_new(col=ifelse(i==2,"white",NA))
   if (i %in% c(3,4))
      panel_raster(p1)
   else if (i %in% 2)
      panel_raster(p2)
   if (i==1)
```

```
      panel_coastline()
   panel_coastline(coast=4,col="#007F00",fill="lightgreen",land=TRUE)
   panel_coastline(coast=3,col="#0000003F",fill="#0000003F")
   panel_coastline(coast=2,col="black",fill="black",density=20
                   ,angle=c(-45,45),lwd=0.25,detail="l")
  # panel_graticule(decor=4)
   panel_annotation(text=as.character(i))
   if (i==1)
      panel_annotation(pos=c(1,1),text="default")
   else if (i==2)
      panel_annotation(pos=c(0,1),text="greyscale")
   else if (i==3)
      panel_annotation(pos=c(1,1),text="land is shadowed")
   else if (i==4)
      panel_annotation(pos=c(0,1),text="ocean is masked")
}
compose_legend(p2,p1)
compose_close()
```

`panel_contour` *Add colored contour to the image panel*

Description

An instrument to overlay multiple rasters on the same image panel. Contour is derived from one band of raster image. The colors (and respective colorbar in legend) is an alternative to contour labeling.

Usage

```
panel_contour(obj, type = "", ...)
```

Arguments

`obj`	Object of class `ursaRaster` or `NULL`. Raster band for contouring. If `NULL` then contour is not displayed. Default is `NULL`.
`type`	Character. Keyword list to descibe characteristics of contour, which is interpreted using regular expressions. `"label"` specifies displaying labels on contour lines. `"line"` specifies displaying contour lines. `"colo(u)*r"` specifies displaying colored contour lines. `"fill"` specifies displaying filled contour lines. Keywords can be combined in a single character, e.g., `"fill label"` specifies displaying filled contours with labels.
`...`	Set of arguments, which are recognized via their names (using regular expressions) and classes:

bg Character. Color name or code for contour border. Used for contrast increasing. Semi-transparency and transparency ("transparent") are allowed. Default is "black".

lwd(\\.fg)* Positive numeric. Width of contour line. Default is 1.

lwd\\.bg Poistive numeric. Width of the back of contour line. For bordering shoould exceed foreground width (argument lwd). Default is lwd*1.5.

lty Numeric of character. Line type for contour. Default is 1.

(lab)*cex Numeric. Character expansion factor for labels. Default is 0.85.

method Character. Argument, which is passed to contour. Default is "flattest".

expand Numeric. Scale factor (>=1) to artificial increasing contour details by means of smoothing of increased image size. Not applicable for images with color tables. Default is NA; smoothing is determined intuitively.

before Logical. Should image reclassification be done before smoothing? Default is FALSE for categorical images and TRUE for numerical images.

cover Numeric. Argument, which is passed to regrid to control NA values during smoothing. Default is NA; connected to default value of argument cover in function regrid.

short Positive integer. Minimal number of points in segments for displaying. Prevents displaying very short segments in the case of high-detailed image. Default is 0: all segments are displayed.

verb(ose)* Logical. Value TRUE may provide some additional information on console. Default is FALSE. Other arguments are used in the functuion colorize to produce color tables.

Details

Function contourLines is used for contouring.

The color table of input raster image is kept. The output panel have one element left, because contours are borders between areas of the same color. It is recommended to use only gradient palettes.

The color table is forced not to be ramp (argument ramp=FALSE in the function colorize) to prevent extra density of contour lines.

The color table is forced to be interval (argument interval=1L in the function colorize) to prevent lost of elements in the palette.

Value

Object of class ursaColorTable, which then should be used as an input argument for the colorbar legend (function legend_colorbar). If there is no argument of class ursaRaster then function returns NULL value.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

contourLines

contour

Examples

```
session_grid(NULL)
a <- pixelsize()
refval <- seq(450,650,by=25)
val <- refval[seq(refval) %% 2 == 1]
ref <- colorize(a,breakvalue=refval,pal.rich=45,pal.rotate=0)
p1 <- colorize(a,breakvalue=val,pal.rich=135,pal.rotate=0)
p2 <- colorize(a,value=val,pal.rich=-15,pal.rotate=0)
p3 <- colorize(a,value=refval)

if (exam1 <- TRUE) {
   compose_open(legend=list(list(1,"left"),list(1,"right")),scale=2)
   panel_new()
  # ct1 <- panel_raster(ref)
  # ct2 <- panel_contour(p2,"colored line",palname="Greens",lwd=15,lwd.bg=0)
   ct2 <- panel_contour(p2,"colored line",pal.rich=240,pal.rotate=0,lwd.fg=15,lwd.bg=0)
  # panel_contour(ref,lwd=0)
  # mysource("contour.R")
  # mycontour(.panel_contour(a),lwd=0)
   if (exists("ct1"))
      compose_legend(ct1,units="raster")
   if (exists("ct2"))
      compose_legend(ct2,units="contour")
   compose_close(bpp=8)
}

if (exam2 <- TRUE) {
   compose_open(layout=c(2,2),byrow=FALSE
               ,legend=list(list(1,"left"),list("bottom",1)
                           ,list(1,"right"),list("top",2)
                           ,list(2,"right"),list("bottom",2)))
   panel_new()
   panel_raster(ref)
   panel_contour(a)
   panel_new()
   ct0 <- panel_contour(a,"color",value=val,pal.rich=240,pal.rotate=0,lwd=11,lwd.bg=12)
   panel_contour(a)
   panel_annotation(text="no colortable")
   panel_new()
   panel_raster(p1)
   ct1 <- panel_contour(p1,"color",lwd=11,lwd.bg=2)
   panel_contour(a)
   panel_annotation(text="colortable:category")
   panel_new()
   panel_raster(p2)
   ct2 <- panel_contour(p2,"color",lwd=11,lwd.bg=2)
   panel_contour(a)#,cex=0.5)
```

```
   panel_annotation(text="colortable:interval")
   compose_legend(ref,units="reference")
   compose_legend(ct0,units="contour")
   compose_legend(p1,units="raster")
   compose_legend(ct1,units="contour")
   compose_legend(p2,units="raster")
   compose_legend(ct2,units="contour")
   compose_close()
}

if (exam3 <- TRUE) {
   s <- 29
   session_grid(NULL)
   a <- as.ursa(volcano)
   if (FALSE) {
      display(a)
      a2 <- regrid(a,mul=s,cascade=TRUE,verbose=TRUE)
      display(a2)
      session_grid(a)
   }
   compose_open() ## device="windows")
   panel_new()
   ct1 <- panel_raster(a,ramp=FALSE,interval=TRUE)
   ct2 <- panel_contour(a,"label")
   rm(ct2)
   panel_decor()
   if (exists("ct2"))
      legend_colorbar(ct2)
   else if (exists("ct1"))
      legend_colorbar(ct1)
   compose_close()
}
```

`panel_decor` *Add auxiliary elements to the plotting panel.*

Description

`panel_decor` adds over plot sequentially the followed elements: coastline, gridline, scalebar. Unlike `panel_decor`, function `layout.grid` does not add scalebar.

Usage

```
panel_decor(...)
```

Arguments

`...`	Passed to sequence of plotting functions:

- panel_graticule. To distinguish the same argument names in different functions it is provided to use prefix "grid.*", e.g., grid.col="grey40".
- panel_coastline. To distinguish the same argument names in different functions it is provided to use prefix "coast.*", e.g., coast.col="grey60".
- *(not applicable for* layout.grid*)* panel_scalebar. To distinguish the same argument names in different functions it is provided to use prefix "scalebar.*", e.g., scalebar.col="black".

Details

The sequence of elements is constant. To change order, use direct calling of panel_graticule, panel_coastline, panel_scalebar in any sequence.

Sometimes, for rasters with NA values the followed sequence may be used:

```
panel_coastline(col="transparent",fill="grey80")
panel_raster(a)
panel_coastline(col="grey40")
```

Value

panel_decor returns NULL value.
layout.grid returns NULL value.

Author(s)

Nikita Platonov <platonov@sebin.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=1,min=0,max=100)
a[a<30] <- NA
compose_open()
panel_new()
ct <- panel_raster(a)
panel_decor(graticule.col="green4",graticule.lwd=2,scalebar.col="brown")
compose_legend(ct)
compose_close()
```

---

panel_graticule *Add latitude/longitude or metric grid to the image panel.*

Description

panel_graticule puts a grid on the panel with raster image. If CRS is georeferenced then grid is generated from longitudes and latitudes.

Usage

```
panel_graticule(...)

compose_graticule(...)

# non-public
.compose_graticule(panel = 0L, col = "grey70", border = "grey70", lon = NA, lat = NA,
                lwd = 0.5, lty = 2, marginalia = rep(FALSE, 4), trim = FALSE,
                language = NA_character_, cex = 0.75, verbose = FALSE)

# non-public
.panel_graticule(obj, marginalia = rep(TRUE, 4), verbose = FALSE)
```

Arguments

...	Set of arguments, which are recognized via their names (using regular expressions) and classes:

Matched pattern	*Used argument*	*Description*
(graticule|grid(line)*)		Logical. Responsible for should grid lines be displayed or no
^(graticule|grid(line)*)$	panel	*See below*.
(graticule|grid(line)\.)*col	col	*See below*. Default value in compose_graticule depends on
(graticule|grid(line)\.)*border	border	*See below*. Default value in compose_graticule depends on
(graticule|grid(line)\.)*lon	lon	*See below*.
(graticule|grid(line)\.)*lat	lat	*See below*.
(graticule|grid(line)\.)*lwd	lwd	*See below*.
(graticule|grid(line)\.)*lty	lty	*See below*.
(decor|margin(alia)*)	marginalia	*See below*. .compose_graticule and .panel_graticule do
((graticule|grid(line)\.)*trim	trim	*See below*.
(graticule|grid(line)\.)*language	language	*See below*.
(graticule|grid(line)\.)*verb(ose)*	verbose	*See below*.

obj	Objects of the class ursaGridLine. It is internal structure, which is returned by function .compose_graticule.
panel	Integer vector. Panel for which coastline will be displayed. 0L means that coastline will bw displayed for all panels. Default is 0L.
col	Character. Color code/name for grid lines. Default is "grey70".
border	Character. Color code/name for marginal labels and ticks. Default is "grey70".
lon	Numeric vector. Set of longitudes for grid. If NA then set of logitudes is formed internally. Default is NA.
lat	Numeric vector. Set of latitudes for grid. If NA then set of latidudes is formed internally. Default is NA.
lwd	Positive numeric. Width of grid line. Default is 0.5. See lwd in par.
lty	Positive integer. Type (pattern) of grid line. Default is 2 (dashed). See lty in par.

marginalia	Logical or integer vectors. Responsible for whether longitudes and latitudes (or metric coordinates) be labelled on the frame of panel with raster image. If logical and TRUE, then labels will be displatyed on each open side of panel. If logical and FALSE then labels will not be displayed. If logical of length 4, then labels will be displayed on specific side, where side index is c(bottom, left, top, right) (see description for marginal parameters in par). If argument is a vector of positive integers, then labels for grid lines are plotted only for the specified panels, which sequence is defined in compose_design function and returned from getOption("ursaPngLayout")$layout. Default is c(TRUE,TRUE,TRUE,TRUE).
language	Character. Language for longitude and latitude captions. If "ru" then captions are in Russian else in English. Default is NA.
trim	Logical. If grid lines are labelled then trim=TRUE prevents crossing the labels on neighbor perpendicular sides.
cex	Positive numeric. The relative font size for grid lines' labels. Make sence in the case of labels plotting. Default is 0.75.
verbose	Logical. Value TRUE may provide some additional information on console. Default is FALSE.

Details

If not language="ru" but environmental variable LANGUAGE=ru then labels are in Russian (cyrillics).

Argument gridline (or, grid) is introduced for unconditional calling of panel_graticule inside of high-level functions.

Grid lines can be controlled in high-level plot functions (*e.g.*, display, compose_plot, display_stack, display_brick, display_rgb, *etc*.). To prevent displaying grid lines, use argument gridline=FALSE (or grid=FALSE). To display grid lines, use argument gridline=TRUE (or grid=TRUE) and prefix grid(line)* (gridline.* or grid.*) for grid lines' parameters, *e.g.*, gridline.verb=TRUE, grid.col="black". If prefix is omitted then arguments with the same names affect in other functions in the part of high-level function.

If grid lines are formed internally, then desirable number of lines for each direction is 3. The design of line density is based on intuition, providing pretty labelling.

If CRS is georeferenced then grid lines are corresponded to longitudes and latitudes. Integer minutes are used to illustate fractional values of degrees. If precision of minutes is insufficient, then integer values of seconds are introduced. The fractional values of seconds are not used.

Labels are located at the points, where grid lines cross plot margin. Labels are not overlapped along the same side. To prevent overlapping along the same side, labels are shifted or omitted. Argument trim=TRUE prevents overlapping labels from neighbor sides via hidding.

Value

Function returns NULL value.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
 ## Changing of environmental variables is out of CRAN Policy
## Not run: Sys.setenv(LANGUAGE="ru")


# example no.1
cl <- compose_design(layout=c(2,2),legend=NULL)
session_grid(regrid(lim=3.2*1e6*c(-1,-1,1,1)))
compose_open(cl)
for (i in 1:4) {
   panel_new()
   panel_coastline()
   panel_graticule(decor=TRUE,trim=i %in% c(2:4))
   panel_annotation(text=as.character(i))
   panel_scalebar(scalebar=i==3)
}
compose_close()

# example no.2
session_grid(regrid(lim=1e6*c(-0.5,0.5,1.5,2.5)))
compose_open(layout=c(2,2),legend=NULL,skip=4)
for (i in seq(getOption("ursaPngLayout")$image)) {
   panel_new()
   panel_coastline()
   if (i==1)
      panel_graticule()
   else if (i==2)
      panel_graticule(decor=TRUE,lon=seq(0,360,by=40)[-1],lat=seq(-90,90,by=10))
   else if (i==3)
      panel_graticule(decor=TRUE,lon=seq(0,360,by=20)[-1],lat=seq(-90,90,by=5)
                      ,trim=TRUE)
   else if (i==4)
      panel_graticule(gridline=FALSE)
   panel_scalebar(scalebar=1)
   panel_annotation(text=as.character(i))
}
compose_close()

# example no.3 -- indirect usage
session_grid(NULL)
display(pixelsize(),decor=TRUE,grid.col="green3",coast.col="darkgreen",side=2)

 ## Changing of environmental variables is out of CRAN Policy
## Not run: Sys.setenv(LANGUAGE="") # reset environmental variable
```

---

panel_new *Start plotting on the new image panel*

Description

panel_new finishes plotting on previuos image panel and starts plotting on next image panel.

Usage

```
panel_new(...)

# non-public
.panel_new(col = "chessboard", alpha = NA, density = NA, angle = NA,
         lwd = 1, lty = 1, asp = NA, mar = rep(0, 4), grid = NULL, verbose = FALSE)
```

Arguments

...	Set of arguments, which are recognized via their names (using regular expressions) and classes. Passed to non-public .panel_new. Optional prefix "blank" is used for indirect use. Separated by a dot ".", e.g., blank.fill="transparent".

Pattern (panel_new)	**Argument** (.panel_new)	**Description**
(blank\\.)*(^$|bg|fill)	col	*See below.* Keyword "chessboard" is used by default to produce
(blank\\.)*aphpa	alpha	*See below.*
(blank\\.)*density	density	*See below.*
(blank\\.)*angle	angle	*See below.*
(blank\\.)*lwd	lwd	*See below.*
(blank\\.)*lty	lty	*See below.*
(blank\\.)*asp	asp	*See below.*
(blank\\.)*mar	mar	*See below.*
(blank\\.)*grid	grid	*See below.*
(blank\\.)*verb(ose)*	verbose	*See below.*

col	Character. Color code/name for panel filling/shadowing. Default is "chessboard" (lightened background for controlling transparency) for georeferenced images, and "grey90" for non-projected images.
alpha	Numeric, 0 <= alpha <= 1. Level of transparency. Default is 1, without transparency.
density	Numeric. The density of shading lines for fill/shadowing. If NA then no shading lines are drawn. Default is NA. See density in rect.
angle	Numeric. The slope of shading lines, given as an angle in degrees (counter-clockwise). If NA then no shading lines are drawn. Default is NA. See angle in rect.
lwd	Positive numeric. Width of coastline. Default is 1. See lwd in rect.
lty	Character or positive integer. Type (pattern) of coastline. Default is 1L (solid). See lty in rect.
asp	Positive numeric. The *y/x* aspect ration. Default is 1. See asp in plot.window.
mar	Positive numeric of length 4. Plot margins. Default is rep(0,4L). See mar in par.

grid	Object of class ursaGrid or converted to it, to define spatial extent and projection for this panel. Default is NULL, which repeats previous state.
verbose	Logical. Value TRUE may provide some additional information on console. Default is FALSE.

Details

Prefix blank is introduced for manipulations with panel_new inside of high-level functions (e.g., display). Prefix skipping is the subject for confict with functions, which use the same name of arguments.

It is required to call panel_new for every image panel. First calling starts plotting on the first panel. Second and next callings change image panels.

The panel sequence is set in function compose_design, which is called directly or indirectly from compose_open, and keeps in the options (access via getOption("ursaPngLayout")$layout).

Image background is formed via consecutive call of functions plot(...,type="n"), and rect(...).

Value

Function returns NULL value.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
# example no.1 -- direct use
compose_open(layout=c(1,3),legend=NULL)
panel_new()
panel_annotation(label="Default + Empty")
panel_new(col="#0000FF3F",density=15,angle=45,lwd=3)
panel_decor()
panel_annotation(label="Settings + Grid")
panel_new("#FFFF0040",grid=regrid(expand=0.5))
panel_decor()
panel_annotation(label="Another spatial extent")
compose_close()

# example no.2 -- indirect use
a <- pixelsize()
a <- a[a>560]
display(a,blank.col="#0000FF3F",blank.density=15,blank.angle=45,blank.lwd=3
       ,coast.fill="#007F005F",coast.density=20,coast.angle=c(-30,60))
```

panel_plot *Add graphical elements to the image panel*

Description

Standard fuctions for plotting from package **graphics** are used for manual adding elements to current plot. Theses series of functions used that standard instruments with additional controling the acceptability of plotting.

Usage

```
panel_plot(obj,...)

panel_box(...)
panel_lines(...)
panel_points(...)
panel_text(...)
panel_abline(...)
panel_polygon(...)
panel_segments(...)
```

Arguments

obj	R object.
...	In panel_plot arguments are passed to function plot. In panel_box arguments are passed to function box. In panel_lines arguments are passed to function lines. In panel_points arguments are passed to function points. In panel_text arguments are passed to function text. In panel_abline arguments are passed to function abline. In panel_polygon arguments are passed to function polygon. In panel_segments arguments are passed to function segments.

Details

If unable to get value TRUE from getOption("ursaPngPlot") then plotting is disable, and any function from this series returns NULL.

Generally, for spatial objects argument add=TRUE is used in panel_plot.

Value

For spatial objects (simple features from **sf** or spatial abstract classes from **sp**) function panel_plot returns object of class ursaLegend. It is a list with items, which can be used to as arguments of legend(). This is intermediate step for experimental feature (not ready) to display colorbars on plot panel. For other objects function panel_plot returns value of function plot.

Function panel_box returns value of function box.
Function panel_lines returns value of function lines.
Function panel_points returns value of function points.
Function panel_text returns value of function text.
Function panel_abline returns value of function abline.
Function panel_polygon returns value of function polygon.
Function panel_segments returns value of function segments.

Note

For plotted elements it is possible to create legend for colors using color bars. No shapes kind and size, no line widths.

To convert object x of class ursaLegend to object of class ursaColorTable please use ursa_colortable(x).

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

panel_contour

Package **graphics** (help(package="graphics")) and functions plot, box, lines, points, text, abline, polygon, segments.

Examples

```
session_grid(NULL)
# require(rgdal) ## 'rgdal' is retired
a <- pixelsize()
g1 <- session_grid()
n <- 12L
k <- 5L
x <- with(g1,runif(n,min=minx,max=maxx))
y <- with(g1,runif(n,min=miny,max=maxy))
panel_plot(x,y) ## plots nothing, because 'compose_open(...,dev=F)' is not called yet
shpname <- tempfile(fileext=".shp")
layername <- gsub("\\.shp$","",basename(shpname))
if (requireNamespace("sp")) {
   sl <- lapply(seq(k),function(id){
      x <- sort(with(g1,runif(n,min=minx,max=maxx)))
      y <- sort(with(g1,runif(n,min=miny,max=maxy)))
      sp::Lines(sp::Line(cbind(x,y)),ID=id)
   })
   sl <- sp::SpatialLines(sl,proj4string=sp::CRS(ursa_proj(g1)))#,id=length(sl))
   lab <- t(sapply(sp::coordinates(sl),function(xy) xy[[1]][round(n/2),]))
   lab <- as.data.frame(cbind(lab,z=seq(k)))
   sl <- sp::SpatialLinesDataFrame(sl
                ,data=data.frame(ID=runif(k,min=5,max=9),desc=LETTERS[seq(k)]))
   print(sl@data)
   ct <- colorize(sl@data$ID)#,name=sldf@data$desc)
```

```
  try(writeOGR(sl,dirname(shpname),layername,driver="ESRI Shapefile")) ## 'rgdal' is retired
   spatial_write(sl,shpname)
} else if (requireNamespace("sf")) {
   sl <- lapply(seq(k),function(id) {
      x <- sort(with(g1,runif(n,min=minx,max=maxx)))
      y <- sort(with(g1,runif(n,min=miny,max=maxy)))
      sf::st_linestring(cbind(x,y))
   })
   sl <- sf::st_sfc(sl,crs=as.character(ursa_crs(g1)))
   sl <- sf::st_sf(ID=runif(k,min=5,max=9),desc=LETTERS[seq(k)],geometry=sl)
   print(spatial_data(sl))
   lab <- do.call("rbind",lapply(sf::st_geometry(sl),colMeans))
   lab <- as.data.frame(cbind(lab,z=seq(k)))
   ct <- colorize(sl$ID)
   sf::st_write(sl,shpname)
}
compose_open(layout=c(1,2),legend=list(list("bottom",2)))
panel_new()
panel_decor()
panel_lines(x,y,col="orange")
panel_points(x,y,cex=5,pch=21,col="transparent",bg="#00FF005F")
panel_points(0,0,pch=3)
panel_text(0,0,"North\nPole",pos=4,cex=1.5,family="Courier New",font=3)
panel_new()
panel_decor()
if (exists("sl"))
   panel_plot(sl,lwd=4,col="grey20")
if ((exists("ct"))&&(file.exists(shpname)))
   panel_plot(shpname,lwd=3,col=ct$colortable[ct$index])
if (exists("lab"))
   panel_points(lab$x,lab$y,pch=as.character(lab$z),cex=2)
if (exists("ct"))
   compose_legend(ct$colortable)
compose_close()
file.remove(dir(path=dirname(shpname)
               ,pattern=paste0(layername,"\\.(cpg|dbf|prj|shp|shx)")
               ,full.names=TRUE))
```

`panel_raster` *Add raster to the image panel*

Description

If specified image has 3 or 4 bands, then color composite is plotted on image panel, else the image is plotted regarding to its color table.

Usage

```
panel_raster(...)
```

Arguments

...	Set of arguments, which are recognized via their names (using regular expressions) and classes. 1. Passed to colorize. 2. interpreted in this function: "(^$|obj)" *as* obj Object of class ursaRaster. Raster band for plotting. Multiple bands are allowed if then can be interpreted as RGB or RGBA. "useRaster" *as* useRaster Logical. If TRUE then a bitmap raster is used to plot the image instead of polygons. See argument useRaster in function image. Default depends on PNG device (getOption("ursaPngDevice"), which is set up in compose_open); it is TRUE for "cairo" device, and FALSE for "windows" device. "interp(olate)*" *as* interpolate Logical. Passed as argument interpolate to function rasterImage. "(alpha|transp(aren(cy)*)*)" *as* alpha Numeric or character. Level of transparency. If numeric, the either 0 <= alpha <= 1 or 0 <= alpha <= 255. If character, then one byte of hexadecimal value "00" <= alpha <= "FF". If NA, then transparency is used from colortable, else transparency of colortable is overwritten by alpha. Default is NA. "verb(ose)*" *as* verbose Logical. Value TRUE may provide some additional information on console. Default is FALSE.

Details

If obj is list of raster images, then panel_raster is applied to each item of list, and colortable of last item is returned.

If obj has 3 or 4 bands then obj is interpreted as RGB(A) image.

Function attempts to speed up plotting by reduce image matrix for big rasters.

Value

If argument obj has strictly one band, then function returns color table - object of class ursaColorTable, which can be used as an input argument for the colorbar legend (function legend_colorbar). Otherwise function returns NULL value.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
# example no.1 -- direct use
session_grid(regrid(mul=1/32))
dima <- with(session_grid(),c(columns,rows,3))
a <- ursa_new(value=array(runif(prod(dima),min=127,max=255),dim=dima))
p <- colorize(a,pal=c("black","white"),ramp=TRUE,value=0:256)
compose_open(layout=c(2,3),skip=4,legend=list(list("top","full"),list("bottom",2:3)))
```

```
for (i in seq(6)) {
   panel_new()
   if (i<4)
      panel_raster(p[i])
   else
      panel_raster(a,interpolate=i==5)
   panel_decor(col="black",coast=FALSE)
   panel_annotation(c("red","green","blue"
                   ,"interpolate=FALSE","interpolate=TRUE"))
}
legend_colorbar(p,label=seq(0,256,by=16),units="channels")
legend_mtext("color composite")
compose_close()

# example no.2 -- indirect use
ps <- pixelsize(NULL)
display(ps,raster.verb=TRUE)

# example no.3 -- color table for legend
session_grid(NULL)
compose_open()
panel_new()
ct <- panel_raster(ps,pal=terrain.colors)
panel_decor()
compose_legend(ct)
compose_close()
```

`panel_scalebar` *Add scale bar to the image panel*

Description

`panel_scalebar` puts a scale bar ('box' style) on the panel with raster image.

Usage

```
panel_scalebar(...)

# non-public
.panel_scalebar(position = "bottomleft", w = NA, cex = 0.85,
                col = "#0000002F", bg = "transparent", fill = "#FFFFFF2F",
                language=NA, verbose = FALSE)
```

Arguments

`...`	Set of arguments, which are recognized via their names (using regular expressions) and classes. Passed to non-public `.panel_scalebar`, excepting argument `scalebar`:

Pattern (panel_scalebar)	**Argument** (.panel_scalebar)	**Description**
(scalebar|ruler|decor)		Logical or integer. Responsible for should scale bar be di
(scalebar\\.)*pos(ition)*	position	*See below*.
(scalebar\\.)*w	w	*See below*.
(scalebar\\.)*cex	cex	*See below*.
(scalebar\\.)*col	col	*See below*.
(scalebar\\.)*fill	fill	*See below*.
(scalebar\\.)*bg	bg	*See below*.
(scalebar\\.)*language	language	*See below*.
(scalebar\\.)*verb(ose)*	verbose	*See below*.

position	Character keyword or numeric of length 2 in the interval [0,1]. Defines the location of scale bar. If character, then one of the "bottomleft", "bottomright", "topleft", "topright", "left", "right", "bottom", "top", or "center". If numeric then relative position on panel is defined using shift on horizontal and vertical axes from origin in the bottom-left corner. Default is "bottomleft".
w	Positive numeric. The length *in km* of scalebar's right segment. If w=NA then length of segment is defined automatically. Default is NA.
cex	Positive numeric. The relative font size for scalebar's labels. Default is 0.85.
col	Character. Primary fill color for scalebar box and scalebar labels. Default is "#0000002F".
fill	Character. Secondary fill color for scalebar box. Default is "#FFFFFF2F".
bg	Character. Background color for the area of scalebar box and labels. Default is "transparent".
language	Character. Language for longitude and latitude captions. If "ru" then captions are in Russian else in English. Default is NA.
verbose	Logical. Value TRUE may provide some additional information on console. Default is FALSE.

Details

The scalebar has 2 left segments and 2 right segments. Left and right segments are separated by 0. The length of left segments is a half of length of right segments.

Argument scalebar (or, synonym, ruler) is introduced for unconditional calling of panel_scalebar inside of high-level functions.

Default x=0 and y=0 define the "bottomleft" position of scale bar.

If argument scale in the function compose_open is character, then the length of one segment is exactly 1 cm, and the total length of scalebar is 3 cm.

If not language="ru" but environmental variable LANGUAGE=ru then labels are in Russian (cyrillics).

The length distortions is taken into account for transverse Mercator ("+proj=tmerc") projection regarding to location of scalebar.

Scalebar (single occurence) can be controlled in high-level plot functions (*e.g.*, display, compose_plot, display_stack, display_brick, display_rgb, *etc.*).

To plot scalebar, use argument `scalebar=TRUE` and prefix `(ruler|scalebar)` (`scalebar.*` or `ruler.*`) for scalebar's parameters, *e.g.*, `scalebar.pos="bottomright"`, `scalebar.cex=0.9`.

Scalebar is not displayed for longlat projection (`"+proj=longlat"`), where units are degrees.

Value

This function returns `NULL` value.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
# example no.1 -- direct usage
   a <- colorize(pixelsize())
   compose_open(a)
   panel_new()
   panel_raster(a)
   panel_graticule()
   panel_coastline()
   panel_scalebar()
   compose_close()

# example no.2 -- indirect usage
   display_rgb(ursa_dummy(nband=3,min=0,max=255),coastline=FALSE
               ,scalebar=TRUE,scalebar.col="white",scalebar.fill="black")

# example no.3 -- for paper copy
   a <- colorize(pixelsize(),breakvalue=seq(400,650,by=50),pal=c("gray90","gray30"))
   compose_open(scale="1:95000000",dpi=150,device="cairo",family="serif")
   compose_plot(a,units=expression(km^2)
                ,graticule=TRUE,coastline=FALSE,scalebar=TRUE,scalebar.pos=c(1,1))
   compose_close(bpp=8)

# example no.4 -- length distortion in the Transverse Mercator projection

   a1 <- regrid(setbound=c(10,65,71,83),dim=c(100,100),crs=4326)
   a2 <- polygonize(ursa_bbox(a1))
   a3 <- spatial_transform(a2,3857)
   a4 <- regrid(setbound=spatial_bbox(a3),res=20000,crs=spatial_crs(a3))
   compose_open(legend=NULL)
   panel_new("white")
   panel_coastline(fill="#00000010",detail="l")
  # panel_graticule()
   for (p in c("bottom","center","top"))
      panel_scalebar(pos=p,w=500)
   compose_close()
```

panel_shading *Shaded overlay by image mask*

Description

This specific function is designed to illustrate linear slope and areas of statistically significant slope on the same panel, however can be used commonly for shading by raster mask.

Usage

```
panel_shading(obj, level = NA, col = NULL, density = 25, angle = c( -45, 45),
                  lwd = 1, lty = 1, verbose = TRUE)
```

Arguments

obj	Object of class ursaRaster.
level	Positive numeric. Threshold for obj reclassification { obj<(-level) | obj>(+level) }. If NULL then mask is created from non-NA values of obj. Default is NULL.
col	ursaColorTable (ursaRaster with color table) or character. Color for shading lines (grid). If object of class ursaColorTable. Two colors on the limits of color vector are extracted to separate source values <=(-level) and >=(+level).
density	Numeric. The density of shading lines, in lines per inch. Default is 25. See description of argument density in function polygon.
angle	Numeric. The slope of shading lines, given as an angle in degrees (counter-clockwise). Default is vector of length two c(-45,45). See description of argument angle in polygon function.
lwd	Numeric. Line width for shading. Default is 1. See description of lwd in par function
lty	Numeric or character. Line type for shading. Default is 1. See description of lty in par function.
verbose	Logical. If TRUE then progresss bar is appeared. Default is TRUE.

Details

Values of input obj is reclassified to raster mask: { values<=(-level) OR values>=(+level) }. For common use, select appropriate level and, if necessary, reclassify obj prior.

Color limits are extracted using range function.

Raster images can be used for colored shading using alpha argument of panel_raster function, e.g. panel_raster(a,alpha=3/4)

Value

NULL

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
if (first.example <- TRUE) {
   session_grid(NULL)
   session_grid(regrid(mul=1/8))
   ps <- pixelsize()
   compose_open()
   ct <- compose_panel()
   panel_shading(ps>1.1*global_mean(ps),angle=90)
   compose_legend(ct)
   compose_close()
}
if (second.example <- TRUE) {
   session_grid(NULL)
   a <- ursa_dummy(nband=15,mul=1/8)
   b <- local_stat(a)
   compose_open()
   lev <- 0.90
   d <- as.matrix(b["slopeS"],coords=TRUE)
   e <- contourLines(d,levels=c(-lev,lev))
   p <- list(significance.raw=colorize(b["slopeS"])
            ,significance.formatted=colorize(b["slopeS"],stretch="significance")
            ,slope=colorize(b["slope"]))
   p <- c(p,rep(p[3],3))
   names(p)[c(3,4,5)] <- c("Slope and shaded significance"
                          ,"Slope and contoured significance"
                          ,"Slope and 'contourLines'")
   compose_open(p,layout=c(2,NA),byrow=FALSE)
   compose_panel(p[1])
   compose_panel(p[2])
   compose_panel(p[3])
   panel_shading(b["slopeS"],level=lev)
   compose_panel(p[4])
   panel_contour(b["slopeS"],value=c(-lev,lev))
   compose_panel(p[5])
   lapply(e,panel_polygon)
   compose_panel(p[6])
   ct <- panel_contour(b["slopeS"],"color"
                      ,value=c(-0.99,-0.95,-0.9,-0.5,0.5,0.9,0.95,0.99))
   compose_legend(c(head(p,-1),'(Colorbar for contours)'=list(ct)),las=3)
   compose_close()
}
```

`pixelsize` *The actual size of each grid cell with considerable distortion in area of map projection.*

Description

This function helps to calculate size of pixels in the unit of area (squared km) for zonal statistics with taking into account distortion in area for classes of projections.

Usage

```
pixelsize(obj, verbose = FALSE)
```

Arguments

obj	Either ursaRaster object or ursaGrid object or NULL or missing.
verbose	Logical. Value TRUE may provide some additional information on console. Default is FALSE.

Details

pixelsize() is applied to coordinate reference system (grid) of ursaRaster object or to raster grid directly. If argument obj is missed, then session grid is used.

Currently, only *Stereographic* ("+stere" in PROJ.4 notation), *Mercator* ("+merc"), and *Lambert Azimuthal Equal Area* ("+laea") classes of map projections are implemented, though the last one (LAEA) has no distortion in area.

Value

Object of class ursaRaster, single-band. If size of cell is more than 10e5 square meters, then the unit is squared kilometers (band name is "Pixel Size (sq.km)") else squared meters (band name is "Pixel Size (sq.m)").

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
pixelsize()

 ## internet connection is required; access was tested on 2018-06-04
invisible({
   dpath <- file.path("ftp://sidads.colorado.edu/pub/DATASETS"
                      ,"nsidc0081_nrt_nasateam_seaice/north")
   dst <- tempfile(fileext=".bin")
   isOK <- FALSE
   d3 <- Sys.Date()
   for (i in seq(5)) {
      src <- file.path(dpath,format(d3,"nt_%Y%m%d_f18_nrt_n.bin"))
      a <- try(download.file(src,dst,mode="wb"))
      if ((is.integer(a))&&(a==0)) {
         isOK <- TRUE
         break
```

```
   }
   d3 <- d3-1
}
if (isOK) {
   g1 <- regrid(bbox=c(-385,-535,375,585)*1e4,res=25*1e3
               ,crs=paste("+proj=stere +lat_0=90 +lat_ts=70 +lon_0=-45"
                         ,"+k=1 +x_0=0 +y_0=0 +a=6378273 +b=6356889.449"
                         ,"+units=m +no_defs"))
   session_grid(g1)
   b <- readBin(dst,integer(),size=1L,n=136492L,signed=FALSE)
   ice <- ursa_new(value=tail(b,-300))
   ice[ice>251] <- NA ## keep Pole
   ice[ice==251] <- 250 ## consider 100% ice at Pole
   ice <- ice/2.5 ## uncategorize
   ice[ice<15] <- 0 ## not ice, if less 15%
   ice[ice>0] <- 100
   extent1 <- band_sum(ice*1e-2*ursa(ice,"cell")^2*1e-6)*1e-6
   extent2 <- band_sum(ice*1e-2*pixelsize(ice))*1e-6
  message(paste("Near real-time Arctic sea ice extent (NASA Team algorithm, NSIDC)"))
   message(sprintf("   Direct area calculation:         %5.2f*1e6 km^2.",extent1))
   message(sprintf("   Distortion in area is corrected: %5.2f*1e6 km^2.",extent2))
}
else
   message("It is failed to get sea ice concentration data.")
})
```

---

plot *Simple display of raster images*

Description

Function image for ursaRaster object calls generic function image.
Function plot for ursaRaster object calls function filled.contour.
Color tables are supported.

Usage

```
## S3 method for class 'ursaRaster'
plot(x, ...)

## S3 method for class 'ursaRaster'
image(x, ...)
```

Arguments

x	Object of class ursaRaster
...	Other parameters. Are passed to or filled.contour or to generic function image.

Details

Usage of both these functions is justified for low-level control of plotting. It is recommended to use high-level function `display`. It is flexible and power instrument for raster images visualization.

Function `as.list` for `ursaRaster` object transforms single band of raster image to a suitable object for plotting via function `image` from package **graphics**

Value

Returned value from `image` or `filled.contour` (both functions are in the package **graphics**)

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

`display`

Examples

```
session_grid(NULL)
a <- pixelsize()
plot(a,asp=1)
image(a,asp=1)
b <- colorize(a,ncolor=15)
plot(b,asp=1)
image(b,asp=1)
```

---

polygonize *Raster to vector (polygon) conversion.*

Description

Representing each raster cell as a polygon. In comparison to common GIS raster to vector conversion, where neighbor cells with the same value are combined to the single polygon, the number of output polygons is equal to number of non-NA values.

Usage

```
polygonize(obj, fname, engine = c("native", "sf"), verbose = NA, ...)
```

Arguments

obj	Object of class ursaRaster.
fname	Missing or character. If specified, then ESRI Shapefile is created. Default is missing.
engine	Character keyword from list c("native", "sf"). Define package with tools for creating spatial data. If suggested packaged **"sp"** is loaded or can be loaded from default location, then "sp" is added to this list. If engine="sf", then functions from package **sf** are used. If engine="sp", then functions from package **sp** are used. If engine="native", then appropriate package is used based on loaded namespaces before.
verbose	Logical. If TRUE then convertion is attended by progress bar. Default is NA; it means TRUE for engine="sp" and FALSE for engine="sp".
...	Additional arguments, which are passed to internal function for writing ESRI Shapefile.
	compress Logical. Should output ESRI Shapefile files be compressed by zip? Default is FALSE.

Details

Some GIS software (e.g., QGIS) has broad tools for display vector data. Excepting choroplets, it is assumed that visualization of each cell separately is more attractive than displaying of polygons with different forms, which are produced, for example, by GDAL convertion utillity gdal_polygonize.py.

Value

If missing fname and tools from **sp** then object of class "SpatialPolygonsDataFrame" (package **sp**).
If missing fname and tools from **sf** then object of class "sf" with geometry of class "sfc_POLYGON" (package **sf**).
If fname is specified, then NULL.

Note

Implementation is very slow even for moderate image size. Use progress bar (verbose=TRUE) to control this process.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy(mul=1/16)
a <- a[a>100]
print(a)
print(band_mean(a))
b2 <- polygonize(a,engine=ifelse(requireNamespace("sp"),"sp","sf"))
print(class(b2))
```

```
print(colMeans(spatial_data(b2),na.rm=TRUE))
str(e1 <- spatial_bbox(a))
str(e2 <- spatial_bbox(b2))
print(as.numeric(e1))
print(as.numeric(e2))
```

`read_envi` *Read ENVI .hdr Labelled Raster file to memory*

Description

Reads all or several bands of ENVI .hdr Labelled Raster file from disk to memory.

Usage

```
read_envi(fname, ...)
```

Arguments

`fname`	Character. Filename for ENVI .hdr Labelled Raster file.
`...`	For `read_envi`: Set of arguments, which are recognized via their names (using regular expressions) and classes. In the case of grids mismatch some arguments (e.g., `resample`) are passed to `regrid` function.

`(subset)*` *Name can be omitted.* Integer or character. If integer, then indices of bands, either positive or negative. Positive indices are for included bands, negative indices for omitted bands. If character, then either sequence of band names or regex string. By default (`subset=NULL`), function reads all bands.

`(ref)*` *Name can be omitted.* `ursaRaster` or `ursaGrid` object. Reference grid for raster image resizing. By default (`ref=NULL`) there is no resizing.

`(nodata|ignorevalue)` Numeric. Value, which is ignored. By default (`nodata=NaN`) igrore value is taken from ENVI metadata (*.hdr or *.aux.xml).

`reset(Grid)*` Logical. If `TRUE`, then session grid is ignored, and new session grid is assigned from input file. If `FALSE`, then input file is nested in the session grid.

`cache` Integer. Using cache for compressed files. `0L` - do not use cache, `1L` - use cache; any other value resets cache. Default is `FALSE`.

`verb(ose)*` Logical. Value `TRUE` may provide some additional information on console. Default is `FALSE`.

Details

Function `read_envi` is designed to one-time reading (from disk to memory) ENVI .hdr Labelled Raster file. For multiple access to disk (by chunks), use followed construction:

```
a <- open_envi(fname)
d1 <- a[condition_1]
d2 <- a[condition_2]
...
close(a)
```

In this case, the connection keeps open. The gain is more effective for compressed binary files.

Value

Object of class `ursaRaster`.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

`open_envi`, *Extract* method `[` for `ursaRaster` object, `close_envi`.

`read_gdal` uses GDAL (**rgdal**) to read ENVI .hdr Labelled Raster file.

Examples

```
session_grid(NULL)
fname <- tempfile()
a <- ursa_dummy()
bandname(a) <- c("first","second","third")
write_envi(a,fname,compress=FALSE)

print(read_envi(fname))
print(read_envi(fname,c(1,3)))
print(read_envi(fname,-c(1,3)))
print(read_envi(fname,c("first","third")))
print(read_envi(fname,"iR"))

print(session_grid())
g <- regrid(session_grid(),mul=1/2.3)
b <- read_envi(fname,ref=g)
print(session_grid())
print(b)

envi_remove(fname)
```

read_gdal *Read GDAL supported raster files.*

Description

read_gdal creates ursaRaster object from GDAL supported raster files using functions from packages with low-level raster reading.

Usage

```
read_gdal(fname, resetGrid = TRUE, band = NULL,
          engine = c("native", "sf"),
          verbose = FALSE, ...)

ursa_read(fname, verbose = FALSE)
```

Arguments

fname	Character. GDAL supported raster file name.
resetGrid	Logical. If TRUE then new sessional grid is based on opened raster image. Default is TRUE
band	Character (regular expression) or integer.
engine	Character. Functionality of which package is used for reading data. This is experimental list, which future depends on evolution of reviewed packages and their availability for partial reading of multiband rasters.
verbose	Logical. Value TRUE may provide some additional information on console. Default is FALSE.
...	Ignored.

Details

ursa_read is simplified implementation of gdal_read.

The composite GDAL formats (e.g., NetCDF: Network Common Data Format, HDF5: Hierarchical Data Format Release 5) are likely unsupported.

read_gdal uses functions from other other packages. It's a wrapper.

Category names and color tables are supported.

Value

Object of class ursaRaster.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

as.ursa is an alternative call for GDAL raster files import.

Examples

```
session_grid(NULL)

# rgdal::gdalDrivers()
if (requireNamespace("sf"))
   print(sf::st_drivers())
if (file.exists(Fin1 <- system.file("gdal/gdalicon.png",package="sf"))) {
   a1 <- read_gdal(Fin1)
   print(a1)
   display(a1)
}
Fin2 <- tempfile(fileext=".")
a <- ursa_dummy(1,resetGrid=TRUE)
b <- colorize(a[a>91],stretch="equal",name=format(Sys.Date()+seq(0,6),"%A %d"))
write_envi(b,Fin2)
b1 <- read_gdal(Fin2)
b2 <- read_envi(Fin2,resetGrid=TRUE)
envi_remove(Fin2)
print(c('same colortable?'=identical(ursa_colortable(b1),ursa_colortable(b2))))
print(ursa_colortable(b1))
print(as.table(b1))
print(c('same values?'=identical(ursa_value(b1),ursa_value(b2))))
print(c('same grid?'=identical(ursa_grid(b1),ursa_grid(b2))))
if (requireNamespace("sf")) {
   p1 <- sf::st_crs(ursa_crs(b1))
   p2 <- sf::st_crs(ursa_crs(b2))
   print(c('same proj4string for CRS?'=identical(p1$proj4string,p2$proj4string)))
   print(c('same WKT for CRS?'=identical(p1$Wkt,p2$Wkt)))
   ursa_crs(b1) <- ursa_crs(b2)
   print(c('after same CRS, same grid?'=identical(ursa_grid(b1),ursa_grid(b2))))
}
display(b1,detail="l")
```

---

reclass *Reclassify specific values of image*

Description

This is look-up table reclassification: the destination value is found for each source value.

Usage

```
reclass(obj, dst = NULL, src = NULL, sparse = FALSE, ...)
```

Arguments

obj	Object of class ursaRaster or ursaColorTable.
dst	Object of class ursaRaster, or object of class ursaColorTable, or numeric vector. If numeric, then the desired destination set of values, else reference object for reclassification; this object should have numerical values of categories.
src	Numerical vector, but allowed using with numerical vector of dst and length(src)==length(dst). Source set of values.
sparse	Logical. If image has a lot of NA values then sparse=TRUE may speed up transformation. Default is FALSE.
...	Other arguments are used for classification in the function colorize.

Details

If dst is numeric vector, then the source value have to be specific, without any ranges. It is required the equality lengths of src and dst. If image has color table then function tries reconstruct dst from names of categories.

This function can be used for data compression for storage, e.g. for distribution or interchange.

Value

If obj is object of class ursaColorTable then numeric vector of categories' centers.

If dst is numeric, then object of class ursaRaster without color table.

If dst is ursaColorTable then object of class ursaRaster (NA values) in color table.

If dst is NULL then object of class ursaRaster with empty color names (NA values) in color table.

Note

There were no a lot of tests how GIS software reads "ENVI .hdr Labelled Raster" files with color tables without color values (only *categories*). At least, GDAL recognizes categories (gdalinfo utility).

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

The reclassification from interval source values to specific destination values is used in colorize.

Examples

```
session_grid(NULL)
# example no.1 manual classification
a <- as.ursa(round(matrix(runif(100,min=0.5,max=3.5),ncol=10)))
print(as.table(a))
b <- reclass(a,src=c(3,1,2),dst=round(runif(3),2))
print(as.table(b))
```

```
print(c(src=a,dst=b))

# example no.2 -- similarity to other object
session_grid(NULL)
a <- ursa_dummy(nband=2,min=-1,max=1)
print(a)
b1 <- colorize(a[1],value=seq(-1,1,length=21),pal.rich=240,pal.rotate=0)
b2 <- reclass(a[2],b1)
b3 <- reclass(a[2],ursa_colortable(b2))
b <- c(b1,b2,b3)
print(reclass(b))

# example no.3 -- compression with data lost
a <- pixelsize(NULL)
b <- reclass(a,byte=TRUE,tail=0) ## try 'byte=FALSE'
a2 <- reclass(b)
res <- c(source=a,as_category=a2,difference=a-a2)
print(res)
message(paste("RMS error: ",format(sqrt(band_sum(res[3]^2)/band_n(res[3])))))
prefix <- names(res)[1:2]
fname <- file.path(tempdir(),paste0(prefix,".envi"))
s <- data.frame(object.size=sapply(list(a,b),object.size))
rownames(s) <- prefix
print(s)
write_envi(a,fname[1])
write_envi(b,fname[2])
f <- file.info(dir(path=tempdir()
                   ,pattern=paste0("(",prefix,")\\.(envi|hdr)",sep="|")
                   ,full.names=TRUE))[,"size",drop=FALSE]
colnames(f) <- "file.size"
print(f)
envi_remove(fname)
```

`regrid` *Change raster image resolution and extent*

Description

General function to change parameters of cells under the same geographical projection. It is implemented via raster resampling to the new grid.

Usage

```
regrid(x, ...)

## non-public
.regrid(grid = NULL, mul = NA, res = NA, resx = NA, resy = NA, setbound = NA,
        columns = NA, rows = NA, dim = NA, bbox = NA, expand = NA,
       minx = NA, miny = NA, maxx = NA, maxy = NA, cut = NA, proj4 = NA, crs = NA,
     border = 0, zero = c("keep", "node", "center"), raster = FALSE, tolerance = NA,
```

```
zoom = NA, adjust = c(0.5, 0.5), verbose = FALSE, ...)
```

Arguments

x	Object of class ursaRaster.
...	1. Arguments, which are passed to non-public .regrid to define parameters of new grid. 2. Set of arguments, which are recognized via their names (using regular expressions) and classes: ^reset(Grid)* Logical. Whether new grid will be defined as a sessional parameter? If TRUE then returned raster defines new sessional grid. If FALSE then session grid is not changed. Default is TRUE. resample Logical or positive numeric. The range of aggregation in the units of cell area. If 0 or FALSE then "nearest neighbor" value is used. The resample>0 defines the side of rectangular area in proportion to cell size; and aggregation of adjacent cells is weighted in proportion to overlapping parts of cells. Default is 1 (or, equally, TRUE); it means that value of output cell is weighted mean of values of overlapped input cells in proportion of overlapping of output cell by input cells. cover Positive numeric in the range [0, 1]. The maximal fraction of NA values in adjusted input cells for the rule to write NA value to the output cell. Default is 0.499. cascade Logical. Option to get more smooth results. If TRUE and resample>2 then resize function is applied sequentially with argument resample<=2. verb(ose)* Logical. Value TRUE may provide some additional information on console. Default is FALSE.
grid	Reference ursaGrid or ursaRaster object. If missing then reference grid is obtained from sessional grid session_grid()
mul	numeric of length 1. Multiplication for changing image size by means of changing of cell size (1/mul). mul>1 decreases cell size, mul<1 increases cell size
res	numeric of length 1 or 2. New grid size by horizontal and vertical axes. If length is 1 then the same grid size for both axes.
resx	Positive numeric of length 1. New grid size by horizontal axis.
resy	Positive numeric of length 1. New grid size by vertical axis.
setbound	numeric of length 4. Change units of spatial extension and define new spatial extension (boundary box) in the notation c(minx,miny,maxx,maxy).
columns	Positive integer of length 1. Number of columns/samples in the case of definition of new spatial extension (setbound is non-NA).
rows	Positive integer of length 1. Number of rows/lines in the case of definition of new spatial extension (setbound is non-NA).
dim	Positive integer of length 2. Dimenstion of raster image in the notation c(rows, columns) (or, c(lines, samples)) in the case of definition of new spatial extension (setbound is non-NA).

bbox	numeric of length 4. New spatial extension (boundary box) in the notation c(minx,miny,maxx,maxy) in the same units of existing spatial extension.
minx	numeric of length 1. New value for left boundary.
miny	numeric of length 1. New value for bottom boundary.
maxx	numeric of length 1. New value for right boundary.
maxy	numeric of length 1. New value for top boundary.
cut	numeric of length 4. Vector (left, bottom, right, top) in CRS units for extent expand.
border	numeric of length 1 or 4. If length 4, then vector (bottom, left, top, right) in cells for extent expand. If length <4, then value is repeated for length 4.
proj4	character of length 1. New projection string in the PROJ.4 notation
crs	character of length 1. The synonym to proj4.
expand	numeric of length 1. Multiplier of boundary box.
raster	logical. Should return blank ursaRaster object instead of ursaGrid object? See 'Value' section
zero	character. Define central cell position relative to zero coordinates. If value is "keep", then central cell position is without changes. If value is "node", then zero coordinates are on the crossing of cell borders. If value is "center", then zero coordinates are in the center of central cell. *Currently is not implemented. If grid is consistent, then value "keep" is used, else "node".*
tolerance	numeric. Threshold for comparison float point numerics. Required for internal check of grid consistence. Default is NA; value .Machine$double.eps multiplied on maximal value of coordinates is used.
zoom	numeric. Tweak for simultaneous change of expand and mul: expand=zoom, mul=1/zoom. Default is NA.
adjust	numeric of length 2. Dragging horizontal and vertical expansion for argument expand. Value 0.0 means expansion to the left or to the bottom. Value 1.0 means expansion to the right or to the top. Value 0.5 means equal horizontal or vertical expansion. Default is c(0.5,0.5).
verbose	Reporting via message about violation and restoration of coordinate grid regilarity after non-consistence usage of parameters.

Details

Generally, argument resample sets a rectangular region. The area of this region is in proportion to area of output cell. Argument resample is the value of this proportion. Each cell is interpreted as a set of adjoining rectangular figures. The value of output cells is a weighted mean of that input cells, which fall into rectangular region. The weights are defined as an partial area inside of rectangular region.

Function implements "nearest neighbor" resampling method if argument resample=0 (or, resample=FALSE). If resample=1 (or, resample=TRUE) and both input and output rasters have the same cell size, then resampling method is "bilinear interpolation".

Expand raster x to 3 times with cell repeating: regrid(x,mul=3,resample=FALSE) ## nearest neighbor;

Expand raster x to 3 times with cell aggregation: `regrid(x,mul=3,resample=TRUE)` ## `bilinear interpolation`;
Contract raster x to 3 times without cell aggregation: `regrid(x,mul=1/3,resample=FALSE)` ## `nearest neighbor`;
Contract raster x to 3 times with cell aggregation: `regrid(x,mul=1/3,resample=TRUE)` ## `weighted mean`;
Low-pass filtering by 3 x 3 window size: `regrid(x,resample=3*3)` ## see `focal_mean`

However, simple contraction `regrid(x,mul=1/2,resample=FALSE)` is implemented as contration with aggregation (`regrid(x,mul=1/2,resample=FALSE)`), because centers or output cells are located in the nodes (crossing of boundaries of input cells).

It seems that for categorical rasters parameter `resample=0` is more suitable, because nearest neigboring does not introduce new values to output raster, excepting coincidence of input cells' nodes and output cell centers.

Usage of `proj4` argument specifies only desirable PROJ.4 string and does not do reprojection.

The violation of grid regualarity is due to columns and rows of image should be integer. The restoration of grid regularity is realized by spatial extension (boundary box) expansion.

Value

`regrid` returns object of class `ursaRaster`.

Return value of non-public function `.regrid` depends on logical value of `raster` argument. If `raster=FALSE` then `.regrid` returns new grid without any change of sessional grid. If `raster=TRUE` then `.regrid` returns blank image and changes sessional grid.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

`regrid`, `focal_mean`

Examples

```
session_grid(NULL)
print(g1 <- session_grid())
print(g2 <- regrid(g1,mul=2))
print(g3 <- regrid(g1,res=50000,lim=c(-1200000,-1400000,1600000,1800000)))
print(g4 <- regrid(g1,res=50000,lim=c(-1200100,-1400900,1600900,1800100),verbose=TRUE))
print(g5 <- regrid(g1,mul=1/4))
print(g6 <- regrid(g1,mul=1/4,cut=c(-1,-2,3,4)*25000))
print(g7 <- regrid(g1,mul=1/4,expand=1.05))
print(session_grid()) ## equal to 'g1'
print(a <- regrid(g1,mul=1/4,border=3,raster=TRUE))
print(session_grid()) ## not equal to 'g1'

session_grid(NULL)
'.makeRaster' <- function(nc=6,nr=8) {
   as.ursa(t(matrix(runif(nc*nr,min=0,max=255),ncol=nc,nrow=nr)))
```

```
}
session_grid(NULL)
a <- .makeRaster(12,18)
expand <- 1/3
a1 <- regrid(regrid(a,mul=expand,resample=FALSE),a,resample=FALSE)
a2 <- regrid(regrid(a,mul=expand,resample=TRUE),a,resample=FALSE)
b <- c('source'=a,'contract'=a1,'aggregation'=a2)
print(b)
display_brick(b,grid=TRUE
             ,grid.lon=(seq(ncol(a)*expand+1)-1)/expand
             ,grid.lat=(seq(nrow(a)*expand+1)-1)/expand)
session_grid(NULL)
a <- .makeRaster(6,8)
expand <- 3
b <- c("source"=regrid(a,mul=expand,resample=FALSE,resetGrid=FALSE)
      ,"simple"=regrid(a,mul=expand,cascade=TRUE,resetGrid=FALSE)
      ,"cascaded"=regrid(a,mul=expand,cascade=FALSE,resetGrid=FALSE))
print(b)
display_brick(b)
session_grid(a)
eps <- 1e-4
r <- c(0,expand^(-2)-eps,expand^(-2)+eps,1,expand^0.5
      ,(expand+2/3)^2-eps,(expand+2/3)^2+eps,99)
g2 <- regrid(mul=expand)
session_grid(g2)
b <- ursa_new(bandname=sprintf("Resample=%.4f",r))
for (i in seq(b))
   b[i] <- regrid(a,g2,resample=r[i])
print(b)
display_brick(b,layout=c(2,NA)
             ,grid=TRUE,grid.lon=seq(ncol(a)+1)-1,grid.lat=seq(nrow(a)+1)-1)
```

`rep` *Replicate bands of raster image.*

Description

`rep` for object of class `ursaRaster` creates new `ursaRaster` objects with repitition of original band sequence.

Usage

```
## S3 method for class 'ursaRaster'
rep(x, ...)
```

Arguments

`x`	Object of class `ursaRaster`
`...`	Further arguments to be passed to or from other methods. Keywords:

`times` Positive integer. Number of times to repeat each band.

If argument has no name, then `times` is assumpted.

Value

Object of class `ursaRaster`.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

`c` for `ursaRaster`.

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/4))
a <- ursa_dummy(nband=3)
print(a)
b1 <- rep(a,by=2)
print(b1)
b2 <- rep(a,length=5)
print(b2)
b3 <- rep(a[3],3)
print(b3)
```

Replace *assign values to the portion of raster images*

Description

This operator is used to set or replace values in portion of bands or lines in `ursaRaster` object in memory or data writing to file.

Usage

```
## S3 replacement method for class 'ursaRaster'
x[i, j, ...] <- value
```

Arguments

`x`	`ursaRaster` object
`i`	Integer or character. If integer, then band index, specifying bands to replace. If character, either list of band names or character sting for `regular expression` to match band index. In the *(spatial, temporal)* interpretation of `ursaRaster` object `j` points to *temporal* component.

j	Mentioned for consistence with internal generic function [<-.
...	Mentioned for consistence with internal generic function [<-. Use regexp=FALSE for matching by match, and regexp=TRUE for matching by Perl-compatible regexps case insensitive grep. Default is FALSE.
value	ursaRaster object or numeric (scalar, matrix, array). The latter is coerced to internal matrix of $value item of ursaRaster object.

Details

Operator \sQuote{[<-} is high-level implementation for data writing. If x$value item is not applicable, then value of ursaRaster is not in memory. In this case the controlled by i and j portion is written to file. If both i and j are missing, then x[] <- value writes values to file wholly.

It is not implemented the simultaneously writing to file portion of bands and portion of lines.

Files (currently, ENVI Binary) are opened for reading and writing.

Value

If values of ursaRaster object are in memory, then modified ursaRaster object with replaced bands or lines.
If values of ursaRaster object are not applicable, then ursaRaster object *as is*.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

Extract

Examples

```
session_grid(NULL)
## Prepare
session_grid(regrid(mul=1/4))
a <- pixelsize()
w <- c("first","second","third","fourth","fifth","sixth")
b1 <- rep(a/mean(a),length(w))+seq(length(w))-1
bandname(b1) <- w
nr <- ursa_rows(b1)
bottom <- (as.integer(nr/2)):nr
write_envi(b1,"tmp1",compress=FALSE,interleave="bil")
b2 <- b1
print(b1)

## Replace
b2[1] <- 10+b1["second"]
b2[2] <- 20
try({
   data(volcano)
   b2[3] <- 30+volcano
```

```
}) ## error: unable to coerce
b2["fourth"] <- 40+as.matrix(b1[3])
b2[5] <- 50+as.array(b1[4])
set.seed(352)
try(b2["six"] <- 60+6+runif(5,min=-1,max=1)) ## Data structures mismatching
print(b2)
print(object.size(b2))

## Write
b3 <- create_envi(b2,"tmp2")
print(object.size(b3))
for (i in chunk_line(b3,0.04))
{
   b3[,i] <- b2[,i]+100
   if (5 %in% i)
      print(object.size(b3))
}
close(b3)
print(object.size(b3))
b4 <- read_envi("tmp2")
print(b4)
envi_remove("tmp[12]")
```

---

seq *Sequence Generation for raster image and coordinate grid*

Description

Set of functions to generate regular sequences of bands, x-/y-cordinates and columns/rows.

Usage

```
## S3 method for class 'ursaRaster'
seq(...)

## S3 method for class 'ursaGrid'
seq(...)

ursa_seqx(obj)
ursa_seqy(obj)
ursa_seqc(obj)
ursa_seqr(obj)
```

Arguments

`...`	Set of arguments, which are recognized via their names (using regular expressions), position and classes. `.*` First argument (position 1). Object of classes `ursaRaster`, `ursaGrid`.

`.*` Second argument (position >1). One-character name. Valid values are in the list `c("z","x","y","c","r","lines","samples")`. `"c"` (`"samples"`) and `"r"` (`"lines"`) specify to generate cell sequence in the horizontal and vertical directions from bottom-left corner, whereas `"z"` specifies to generate sequence of bands. `x` and `"y"` return cell midpoints in spatial dimension.

`obj` Object of classes `ursaRaster`, `ursaGrid`. Missing `obj` is allowed; in this case the session grid is considered.

Details

All ordinal sequences (`axis` is `\dQuote{c}`, `\dQuote{r}`, `\dQuote{z}`) start from `1L`.
`axis=\dQuote{z}` is ignored in the function `seq` for `ursaGrid` object. The returned value is `1L`.

`seq(obj)` for `ursaRaster` objects is suitable for using in cycles across bands.

Value

Functions `ursa_seqx` and `seq(obj, "x")` return x-coordinates of cell midpoints.
Functions `ursa_seqy` and `seq(obj, "y")` return y-coordinates of cell midpoints.
Functions `ursa_seqc`, `seq(obj, "samples")` and `seq(obj, "c")` return sequence of cells in horizontal direction.
Functions `ursa_seqr`, `seq(obj, "lines")` and `seq(obj, "r")` return sequence of cells in vertical direction.
Functions `seq(obj)` and `seq(obj, "z")` for `ursaRaster` object returns sequence of bands.
Function `seq(obj)` and `seq(obj, "z")` for `ursaGrid` object returns `1L`.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/16))
print(session_grid())
a <- ursa_dummy(nband=5)
print(a)
print(seq(a))
print(seq(a,"c"))
print(seq(a,"x"))
print(ursa_seqx())
```

`session` *Get and set sessional parameters for grid, CRS, external software for open PNG files.*

Description

session_grid without arguments returns current grid properties. session_grid with arguments specifies grid, which is used by functions of this package, e.g., for plotting, for opened and created raster images during current session.

session_pngviwer is used to permit external software to open PNG files.

session_tempdir specifies directory for temporal files in some cases.

session_use_experimental_functions allows to use undocumented (experimental) functions.

Group of functions session_proj4, session_crs, session_cellsize, session_bbox extracts certain properties of sessional grid.

Usage

```
session_grid(obj, ...)
session_proj4()
session_crs()
session_cellsize()
session_bbox()
session_dim()

session_pngviewer(allow = NA)
session_tempdir(dst = character())
session_use_experimental_functions()
```

Arguments

obj	Either missing, or NULL, or file name, or object of class ursaRaster, or object of class ursaGrid, or spatial object (simple features (**sf**), spatial abstracts (**sp**)).
allow	Logical. If TRUE then it is allowed to use external software for viewing PNG files. NA is interpreted as TRUE in the case of "Rscript" usage, and interpreted as FALSE in the case of interactive session or "R CMD BATCH" usage. Default is NA.
dst	Character. Directory name for temporal files. Empty character or non-character is interpreted as getwd() in the case of "Rscript" usage, and interpreted as tempdir() in the case of interactive session or "R CMD BATCH" usage. Default is character() (empty character).
...	Optional arguments passing to regrid at first.

Details

session_grid deals with option "ursaSessionGrid": options(ursaSessionGrid=...) or getOption("ursaSessionGrid"

Usage session_grid() without arguments return value of "ursaSessionGrid" option via calling getOption("ursaSessionGrid"). If is.null(getOption("ursaSessionGrid")) then session_grid() returns default CRS.

Usage session_grid(NULL) resets "ursaSessionGrid" option via calling options(ursaSessionGrid=NULL).

The sequential calling

```
session_grid(NULL)
session_grid()
```

returns default CRS. For checking that the option has been reset successfully, use `getOption("ursaSessionGrid")` after `session_grid(NULL)`

`session_proj4` and `session_crs` are synonyms.

Value

Object of class `ursaGrid`. It is a list. Default values are grid parameters of NSIDC polar stereo gridded data of Northern hemispere with nominal gridded resolution 25 km. (https://nsidc.org/data/user-resources/help-center/guide-nsidcs-polar-stereographic-projection)

```
List of 9
 $ columns: int 304
 $ rows   : int 448
 $ resx   : num 25000
 $ resy   : num 25000
 $ minx   : num -3850000
 $ maxx   : num 3750000
 $ miny   : num -5350000
 $ maxy   : num 5850000
 $ proj4  : chr "+proj=stere +lat_0=90 +lat_ts=70.0 +lon_0=-45.0 +k=1
              +x_0=0.0 +y_0=0.0 +a=6378273.000 +b=6356889.449 +units=m +no_defs"
 - attr(*, "class")= chr "ursaGrid"
NULL
```

`session_proj4` and `session_crs` return item `proj4`.

`session_cellsize` returns squared root from multiplication of cell dimension: `sqrt(resx*resy)`.

`session_pngviewer` returns value of `getOption("ursaAllowPngViewer")`.

`session_bbox` returns named numeric of length 4: minimal x-coodrinate (`xmin`), minimal y-coordinate (`ymin`), maximal x-coordinate (`xmax`), maximal y-coordinate (`ymax`).

`session_dim` returns named integer of length 2: number of rows (`lines`) and number of columns (`samples`).

`session_use_experimental_functions` added some non-public functions to current namespaces and returns invisile list of function names.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

Class `ursaGrid`. Use `regrid` to partial grid changing.

Examples

```
session_grid(NULL)
getOption("ursaSessionGrid") ## NULL
(g1 <- session_grid()) ## default
g1$resx <- g1$resy <- 12500
g1$columns <- as.integer(with(g1,(maxx-minx)/resx))
g1$rows <- as.integer(with(g1,(maxy-miny)/resy))
session_grid(g1)
session_grid(NULL)
a <- ursa_new(value=3)
session_grid(a)

print(session_pngviewer())
```

`sort` *Sort multiband raster by band names.*

Description

Changing order of bands based on sorting of band names.

Usage

```
## S3 method for class 'ursaRaster'
sort(x, decreasing = FALSE, ...)
```

Arguments

`x`	Object of class `ursaRaster`
`decreasing`	Logical. Should the sort be increasing or decreasing? Not available for partial sorting. Default is `FALSE`.
`...`	Other arguments, which are passed to S3 method for sorting characters.

Details

Function `sort()` for `ursaRaster` assumes bands reordering based on character band names.

Value

Object of class `ursaRaster`

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
a <- ursa_dummy(nband=7L)
a
sort(a)
sort(a,decreasing=TRUE)
```

`spatial_engine` *Wrapper functions for manipulation with non-raster spatial objects*

Description

These wrappers return iniform properties or do consimilar manipulations for spatial objects of different types: simple features (package **sf**) and abstract class Spatial (package **sp**). Appropriate functionality (*"engine"*) of respective packages is used.

Usage

```
spatial_engine(obj, verbose = FALSE)

spatial_crs(obj, verbose = FALSE)
spatial_proj(obj, verbose = FALSE)
spatial_proj4(obj, verbose = FALSE)

spatial_crs(obj, verbose = FALSE) <- value
spatial_proj(obj, verbose = FALSE) <- value
spatial_proj4(obj, verbose = FALSE) <- value

spatial_bbox(obj, verbose = FALSE)
spatial_bbox(obj, verbose = FALSE) <- value

spatial_data(obj, subset= ".+", drop = NA, verbose = FALSE)
spatial_data(obj, verbose = FALSE) <- value

spatial_geometry(obj, verbose = FALSE)
spatial_geometry(obj, verbose = FALSE) <- value

spatial_geotype(obj, each = FALSE, verbose = FALSE)
spatial_shape(obj, each = FALSE, verbose = FALSE)

spatial_transform(obj, crs, verbose = FALSE, ...)

spatial_coordinates(obj, verbose = FALSE)
spatial_centroid(obj, verbose = FALSE)

spatial_fields(obj, verbose = FALSE)
spatial_colnames(obj, verbose = FALSE)
```

```
spatial_fields(obj, verbose = FALSE) <- value
spatial_colnames(obj, verbose = FALSE) <- value

spatial_area(obj, verbose = FALSE)

spatial_dim(obj, verbose = FALSE)

spatial_count(obj, verbose = FALSE)

spatial_nrow(obj, verbose = FALSE)
spatial_ncol(obj, verbose = FALSE)

spatial_filelist(path = ".", pattern = NA, full.names = TRUE, recursive = FALSE,
                 ignore.case = TRUE)
spatial_dir(path = ".", pattern = NA, full.names = TRUE, recursive = FALSE,
            ignore.case = TRUE)

spatial_basename(fname)
spatial_pattern(fname)

is_spatial(obj, verbose = FALSE)

is_spatial_points(obj, verbose = FALSE)
is_spatial_lines(obj, verbose = FALSE)
is_spatial_polygons(obj, verbose = FALSE)

spatial_intersection(x, y,
                   geometry=c("default", "polygons", "lines", "points", "all"),
                     verbose = FALSE)
spatial_symdifference(x, y, verbose = FALSE)
spatial_difference(x, y, verbose = FALSE)
spatial_union(x, y, byid=NA, verbose = FALSE)
spatial_crop(x, y)

spatial_buffer(obj, dist = 0, quadsegs = 30L, verbose = FALSE)

spatial_trim(obj)

spatial_valid(obj, each = FALSE, reason = FALSE, verbose = FALSE)

spatial_grid(obj)

spatial_bind(...)
```

Arguments

obj	Simple feature (package **sf**) or Spatial abstract class (package **sp**) for all functions, excepting `spatial_geometry<-`. Data frame for *Replace* function `spatial_geometry<-`.

x, y	Objects of simple feature (package **sf**) class or Spatial abstract class (package **sp**). Spatial abstracts are not applicable for `spatial_crop()`.
crs	Projection EPSG code or projection PROJ.4 string.
subset	Pattern to field names (colnames) of attribute table (data frame) for subbsetting using regular expressions. By default, all fields are secected.
drop	Logical. Dropping column of data frame. If TRUE, then vector of data is returned. If FALSE, then structure of data is kept. Default is NA, which is interpreted as TRUE for single column and as FALSE for multiple columns.
value	Value for property assignment in *replacement* functions. Either numeric EPSG code or character PROJ.4 string for `spatial_crs<-` and `spatial_proj4<-`. Spatial object or geometry of spatial object for `spatial_geometry<-`.
path	See description of argument `path` in function `dir`.
pattern	See description of argument `pattern` in function `dir`.
full.names	See description of argument `full.names` in function `dir`.
recursive	See description of argument `recirsive` in function `dir`.
ignore.case	See description of argument `ignore.case` in function `dir`.
quadsegs	Integer. Number of segments per quadrant (fourth of a circle), for all or per-feature. See description for `nQuadSegs` argument of `st_buffer`.
dist	Numeric. Buffer distance for all, or for each of the elements. See description for `dist` argument of `st_buffer`.
byid	Logical. For `spatial_union` function, TRUE does unite of each feature; FALSE returns a single feature that is the geometric union of the set of features; default NA is coerced to FALSE for unary operation (missing y) and to TRUE for binary operation.
fname	Character. Filename (source or packed) of spatial data.
each	Logical. Whether result will be returned for each record (TRUE) or generalized (FALSE). Default is FALSE.
geometry	Character. Desired output geometry for `engine="sf"`. If `"default"` then output geometry is defined internally (e.g., `"polygons"` for polygons intersection). If `"all"` then no output subsetting. Default is `"default"`.
reason	Logical. If TRUE, then the reason for validity ("Valid Geomerty") or invalidity is returned. If FALSE, then logical value of validity is returned. Default is FALSE.
verbose	Logical. Value TRUE provides information on console. Default is FALSE.
...	1) Spatial objects for function `spatial_bind`; 2) Further arguments in function `spatial_transform` passed to `sf::st_transform` or to `sp::spTransform`.

Value

`spatial_engine` returns package name (character string `"sf"` or `"sp"`), which functionality is used for manipulation with spatial object `obj`.

`spatial_crs` and `spatial_proj4` are synonyms, The *Extract* functions return projection string in the PROJ.4 notation; the *Replace* functions change projection property of the object.

`spatial_bbox` (*Extract* function) returns numeric vector of length 4 with names "xmin", "ymin", "xmax" and "ymax".

`spatial_bbox<-` (*Replace* function) assigns boundary bbox to the object; it is valid only for objects of Spatial abstract class (package **sp**).

`spatial_data` (*Extract* function) returns attribute table only, without geometry. Subsetting fields can be specified by argument `subset` using regular expressions. If `drop=TRUE` and selected single column then vector is returned instead of data frame.

`spatial_data<-` (*Replace* function) adds spatial data to the object geomerty. Source data (if presents) are droped.

`spatial_geometry` (*Extract* function) returns only geometry, which format is depended on class of `obj`.

`spatial_geometry<-` (*Replace* function) addes geometry to the object.

`spatial_transform` does a transformation of spatial coordinates to the new CRS and returns object of the same class as class of `obj`.

`spatial_geotype` and `spatial_shape` are synonyms; each returns type of spatial data: "POINT", "LINESTRING", "POLYGON", "MULTIPOLYGON", ...

`spatial_coordinates` returns simplified matrix or list of coordinates of original object.

Extract functions `spatial_fields` and `spatial_columns` return column names of spatial attributive table. `spatial_columns` is synonym to `spatial_fields`.

Replace functions `spatial_fields<-` and `spatial_columns<-` change column names of spatial attributive table. `spatial_columns<-` is synonym to `spatial_fields<-`.

`spatial_area` is valid for polygonal geometry. It returns area of polygons.

`spatial_length` is valid for linear geometry. It returns length of lines.

`spatial_dim` gets dimension of spatial coordinates; it returns either `2L` (XY) or `3L` (XYZ).

`spatial_count` returns number of items of object geometry.

`spatial_nrow` and `spatial_ncol` return number of rows and number of columns of attributive table.

`spatial_filelist` and its synonym `spatial_dir` return list of files with file extensions, which are associated with certain GIS vector formats. The function's basis is `dir`.

`spatial_basename` returns basename (without extension) of file `fname` of spatial object.

`spatial_pattern` returns pattern of `spatial_basename` for using in regular expressions.

`is_spatial` returns logical value does the object belong to the class of spatial data.

`is_spatial_points` returns logical value does the object have point geometry.

`is_spatial_lines` returns logical value does the object have (multi)linestring geometry.

`is_spatial_polygons` returns logical value does the object have (multi)polygonal geometry.

`spatial_intersection` returns intersection of two spatial objects.

`spatial_difference` returns difference of two spatial objects.

`spatial_symdifference` returns symmetric difference of two spatial objects.

`spatial_buffer` returns buffered spatial object.

`spatial_union` returns combined geometry without internal boundaries.

`spatial_crop` returns cropped geometry of first spatial object by second spatial object of boundary box derived from spatial object.

`spatial_trim` returns spatial object without extra attributes added by **ursa** package.

`spatial_grid` generates suitable spatial grid from input vector and returns object of class `ursaGrid`.

`spatial_centroid` returns spatial centroid.

`spatial_bind` returns spatial object concatenated from input spatial objects.

Acknowledgements

The great improvement for development of functions for manipulation with spatial objects has been reached during work in series of projects (2015-2018) for design of marine protected areas in the Arctic.

Author(s)

Nikita Platonov <platonov@sevin.ru>

References

Classes and methods in packages **sf** and **sp** help.

Examples

```
session_grid(NULL)
n <- 1e2
x <- runif(n,min=25,max=65)
y <- runif(n,min=55,max=65)
z <- runif(n,min=1,max=10)
da <- data.frame(x=x,y=y,z=z)
if (requireNamespace("sp")) {
   da.sp <- da
   sp::coordinates(da.sp) <- ~x+y
   sp::proj4string(da.sp) <- "+init=epsg:4326"
   print(spatial_bbox(da.sp))
   print(spatial_crs(da.sp))
}
if (requireNamespace("sf")) {
   da.sf <- sf::st_as_sf(da,coords=c("x","y"),crs=4326)
   print(spatial_bbox(da.sf))
   print(spatial_crs(da.sf))
}
```

`spatial_levelsplit` *Drops spatial object with overlapped geometry to spatial object with non-overlapped geometry.*

Description

Contour (levels after kernel utilization distribution, isochrones and other isolines) polygonizations produces set of polygon layers, which geometry is overlapped. Plot of such polygons may cause the invisibility the less polygon behind the larger polygon. This function makes consequent geometries. Simplifuied, concentrated circles are dropped to non-overlapped rings.

Usage

```
spatial_levelsplit(obj, sep = " - ")
```

Arguments

`obj`	Spatial object, either simple features (package **sf**) or abstract class Spatial (package **sp**)
`sep`	Separator between concatenation of two values

Value

Spatial object, which class is the same as class of `obj`.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
palette("Set3")
radius <- seq(1,length.out=5,by=1)*200
ct <- ursa_colortable(colorize(radius,alpha=0.5,pal=sample(palette(),length(radius))))
origin <- sf::st_sfc(sf::st_point(c(lon=139.2,lat=36.6)),crs=4326)
origin <- spatial_transform(origin,"EPSG:6671")
isopoly <- do.call(spatial_bind,lapply(radius*1e3,function(r) spatial_buffer(origin,r)))
spatial_data(isopoly) <- data.frame(radius=radius)
isointerval <- spatial_levelsplit(isopoly)
isointerval$radius
ct2 <- ursa_colortable(colorize(isointerval$radius,pal=unname(ct)))
session_grid(isopoly,border=20)
compose_open(2,legend=list("left","right"))
compose_panel(isopoly,col=ct
             ,annotation.text="Semi-transparent colors are overlapped")
compose_panel(isointerval,col=ct2
             ,annotation.text="Not overlapped rings")
compose_legend(list(ct,ct2))
compose_close()
```

`spatial_read` *Wrapper functions for reading spatial objects.*

Description

Read either simple features (package **sf**) from disk using appropriate functionality (*"engine"*) of respective packages is used.

Usage

```
spatial_read(dsn, engine = c("native", "sf"))
```

Arguments

`dsn`	Character. File name of spatial object (vector GIS).
`engine`	Character. Functionality of which package is used for reading data. If value is `"sf"`, then package **sf** is used and simple features are returned. If value is `"geojsonsf"`, GDAL driver is GeoJSON and package **geojsonsf** can be loaded, then package **geojsonsf** is used and simple features are returned. If value is `"sp"` and package **sp** can be loaded, then Spatial abstracts (package **sp**) are returned. If value is `"native"` then engine selection depends on has suggested package **sf** been installed and is there possibility to use **geosonjf** for GeoJSON driver.

Details

Currently, list of arguments of this funtion is simplified and can be expanded.

Value

Depending of used engine, either simple features (package **sf**) or Spatial abstracts (**sp**).

Note

For GeoJSON files in the case `engine="geojsonsf"` reading is faster and the order of fields can be rearranged.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

`read_sf`

`spatial_write`

Examples

```
session_grid(NULL)
n <- 1e2
x <- runif(n,min=25,max=65)
y <- runif(n,min=55,max=65)
z <- runif(n,min=1,max=10)
da <- data.frame(x=x,y=y,z=z)
if (requireNamespace("sf",quietly=TRUE)) {
   obj1 <- sf::st_as_sf(da,coords=c("x","y"),crs=4326)
   print(series(obj1))
   fname1 <- file.path(tempdir(),"res1.shp")
   print(fname1)
   spatial_write(obj1,fname1)
   res1 <- spatial_read(fname1,engine="sf")
   print(series(res1))
}
print(spatial_dir(tempdir()))
```

`spatial_write` *Wrapper functions for writing spatial objects.*

Description

Write spatial object to disk. If spatial object is Simple Features, then appropriate functions from package **sf** are used. If spatial objest are abstract of class Spatial (package **sp**) then preliminarly transformation to Simple Features is performed.

Usage

```
spatial_write(obj, fname, layer, driver = NA, compress = "", verbose = FALSE)
```

Arguments

`obj`	Spatial object: Either Simple Features (**sf**) or Spatial Abstract (**sp**). List of spatial objects can be used.
`fname`	Character. File name with or without extension. If extension is missed, then argument `driver` must be specified.
`layer`	Character. Layer name. If missed, then basename of `fname` is used.
`driver`	Character. Driver for specification of output file format. Default is `NA`; value is determined from extension of `fname`.
`compress`	Character or logical. Will output file or list of files be packed after writing and what archive format will be used. Available character values are `""` (default; no compression), `"gz"`, `"gzip"`, `"bz2"`, `"bzip2"`, `"zip"`, `"xz"`. If logical and `TRUE`, then "zip" is used for `driver` "ESRI Shapefile" and "gzip" otherwise. If logical and `FALSE`, then no compression.
`verbose`	Logical. Value `TRUE` provides information on console. Default is `FALSE`.

Details

Based on sf::st_write function with additonal options: compressing of output file(s), coordinates trasforming (to longitudes and latitudes for driver="GeoJSON"), creating multi-layer destination (for driver="SQLite").

Value

invisible NULL.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

write_sf

spatial_read

Examples

```
session_grid(NULL)
n <- 1e2
x <- runif(n,min=25,max=65)
y <- runif(n,min=55,max=65)
z <- runif(n,min=1,max=10)
da <- data.frame(x=x,y=y,z=z)
if (requireNamespace("sf",quietly=TRUE)) {
   obj1 <- sf::st_as_sf(da,coords=c("x","y"),crs=4326)
   print(series(obj1))
   fname1 <- file.path(tempdir(),"res1.shp")
   print(fname1)
   spatial_write(obj1,fname1)
   res1 <- spatial_read(fname1,engine="sf")
   print(series(res1))
}
print(spatial_dir(tempdir()))
```

---

summary *Summary of raster image.*

Description

Function summary for ursaRaster object produces summaries for each band.
Function summary for ursaValue object produces summaries for all values of raster image regardless of bands.

Usage

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

## S3 method for class 'ursaNumeric'
summary(object, ...)

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

Arguments

object	Object of classes ursaRaster, ursaNumeric, or ursaCategory
...	Additional arguments affecting the summary produced.

Details

summary for ursaRaster object applies summary to each column of two-dimensions value matrix and collating the results.
summary for ursaValue object drops dimensions and applies summary to a vector.

Value

summary for ursaRaster object returns value of function summary.matrix.
summary for ursaValue object returns object of class \dQuote{summaryDefault}.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

summary in package **base**.

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/4))
a <- ursa_dummy(nband=3)
print(summary(a))
print(summary(ursa_value(a)))
print(a)
```

`temporal_interpolate` *Fill gaps across bands using moving mean window*

Description

`temporal_interpolate` is applicable for multiband raster image, where bands are regular timestamps or period. For each cell (*local* operation of map algebra), `NA` value is replaced by averaging of two closest values (one value before, one value later) inside of moving window.

Usage

```
temporal_interpolate(obj, win = 7, cover = 0, verbose = FALSE)
```

Arguments

`obj`	Object of class `ursaRaster` or `matrix`, where spatial locations are by rows and temporal observations are by columns.
`win`	Positive integer. Size of moving window. Required odd value; otherwise is coerced to the closest odd integer.
`cover`	***Not applicable***. For consistence call with `temporal_mean`.
`verbose`	Logical. `TRUE` provides some additional information on console. Default is FALSE.

Details

Function uses weighted averaging depending of proximity of found non-`NA` values. For example, if `ind` is temporal index of `NA` value in the center of movind window, `indL=ind-2` is temporal index of the closest early value `valL`, and `indR=ind+1` is temporal index of the closest late value `valR`, then result is `val <- (1/3) * valL + (2/3) * valR`.

Value

`ursaRaster` object, if `obj` is object of class `ursaRaster`.

`matrix` object, if `obj` is a matrix.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

`temporal_mean`

Examples

```
session_grid(NULL)
n <- 45 # bands
m <- 3 # sample size
k <- median(seq(n))+seq(m)-(m %/% 2)-1 ## sample subset
s <- 5 # window size
a <- round(ursa_dummy(n,min=-60,max=60,elements=15,mul=1/8))
a[a<(-40)] <- NA
b <- temporal_interpolate(a,7)
p1 <- colorize(a,lazy=TRUE)
p2 <- colorize(b,lazy=TRUE,colortable=p1)
display(list('Source'=p1[k],'Gaps are filled'=p2[k]),layout=c(2,NA)
       ,legend=list(list(1,"right"),list(2,"right")),decor=FALSE)
```

---

temporal_mean *Smooth value across bands using moving mean window*

Description

`temporal_mean` is applicable for multiband raster image, where bands are regular timestamps or period. For each cell (*local* operation of map algebra), the values are averaged using moving window.

Usage

```
temporal_mean(obj, win = 7, cover = 0, verbose = FALSE)
```

Arguments

`obj`	Object of class `ursaRaster` or matrix, where spatial locations are by rows and temporal observations are by columns.
`win`	Positive integer. Size of moving window. Required odd value; otherwise is coerced to the closest odd integer.
`cover`	Numeric in the interval `0` <= `cover` <= `1` or positive numeric >1. The required amount of non-`NA` elements in window to do a filtering. Otherwise, `NA` value is in output cell. If `cover<=1` then amount is relative to window size. Default is `0`: `NA` values are produced only if all elements in window have `NA` value.
`verbose`	Logical. `TRUE` provides some additional information on console. Default is FALSE.

Details

`temporal_mean` is similar to function `runmean(x=obj, k=win, endrule="mean")` from package **caTools**.

Value

`ursaRaster` object, if `obj` is object of class `ursaRaster`.

`matrix` object, if `obj` is a matrix.

Advanced

`temporal_mean` is only smoothing of time-series. For time-series analysis and processing it is suggested to apply lower-level approach.

`as.matrix` (for `ursaRaster` object with argument `coords=FALSE`) or `ursa_value` return matrix with spatial component by rows and temporal component by columns. It is possible to use `apply` with argument `MARGIN=1` to this matrix. If `apply` returns matrix `Y`, then this matrix can be coerced to `ursaRaster` object by calling `as.ursa` with argument `t(Y)`.

```
X <- as.matrix(obj)
Y <- apply(X, 1, function(x) {y <- do_something_return_matrix(x); y})
res <- as.ursa(t(Y))
```

For example, package **caTools** provides some functions for manipulation with moving window.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

References

Package **caTools** https://CRAN.R-project.org/package=caTools

See Also

`caTools::runmean` (click if package **caTools** is installed)

Examples

```
session_grid(NULL)
set.seed(352)
n <- 45 # bands
m <- 3 # sample size
k <- median(seq(n))+seq(m)-(m %/% 2)-1 ## sample subset
s <- 5 # window size
a <- round(ursa_dummy(n,min=-60,max=60,elements=15,mul=1/8))

 ## namespace of package 'caTools' is required
if (requireNamespace("caTools")) {
   b1 <- as.ursa(t(apply(as.matrix(a),1,caTools::runmean,k=s,endrule="mean")))
   b2 <- temporal_mean(a,s)
   print(b1[k])
   print(b2[k])
   print(c('identical?'=all.equal(ursa_value(b1),ursa_value(b2))))
}
```

```
a[a<(-40)] <- NA
va <- as.matrix(a) # or 'ursa_value(a)'
b3 <- temporal_mean(a,s,cover=3/4,verbose=TRUE)
b4 <- as.ursa(temporal_mean(as.matrix(va),s,cover=3/4,verbose=TRUE))
p <- list('Before moving window'=a[k]
         ,'After moving window'=b3[k]
         ,'\'temporal_mean\' to matrix'=b4[k])
print(p)
print(c('identical?'=all.equal(ursa_value(b3),ursa_value(b4))))
display(p[1:2],legend=list(list(1,"right"),list(2,"right")),decor=FALSE)
```

`trackline` *Create segmented line from points' sequence*

Description

Connect sequence of points (locations) by direct lines (tracks)

Usage

```
trackline(obj, by=NULL, connect=c("united", "consequent"), gentle=FALSE)
```

Arguments

`obj`	Simple feature (package **sf**) or Spatial abstract class (package **sp**) with POINTS spatial geometry.
`by`	Either field name or `NULL`. If specified, then value `"united"` is applied for argument `connect`, returned spatial object is splitted regarding values of `by` with linked single-column attribute table with specified field. Default is `NULL`.
`connect`	Structure of output segments; either sequence of single segments (`"consequent"`) or single multi-segment (`"united"`).
`gentle`	Logical. Value `TRUE` directs repetition of binded columns of data table. Value `FALSE` omits duplicated column values. Default is `FALSE`.

Details

Function generates `n-1` segments from `n` input points. Data (attribute table) is trasfered to output object with excluding of first row.

`gentle=TRUE` may be useful to keep geterogenic data structure for spatial binding (`spatial_bind`).

Value

Simple feature (package **sf**) or Spatial abstract class (package **sp**) with LINESTRING spatial geometry.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
n <- 15
lon <- rev(sort(runif(n,min=40,max=60)))
lat <- sort(runif(n,min=30,max=50))
pt <- data.frame(lon=lon,lat=lat,value=seq(n))
if (requireNamespace("sp")) {
   sp::coordinates(pt) <- c("lon","lat")
   sp::proj4string(pt) <- "EPSG:4326"
} else {
   pt <- sf::st_as_sf(pt,coords=c("lon","lat"),crs="WGS84")
}
ct <- ursa_colortable(colorize(pt$value))
tr <- trackline(pt,connect="consequent")
#opW <- options(warn=0)
session_grid(pt,expand=1.1)
compose_open(2)
panel_new()
panel_plot(pt,col=ct)
panel_decor()
panel_new()
panel_plot(tr,col=ct,lwd=3)
panel_decor()
compose_legend(ct,unit="step number")
compose_close()
```

`ursa` *Get and set properties of raster image.*

Description

For package description see.

`ursa` is a wrapper to initialize object of class `ursaRaster`, to get and to set properties for this object.

Usage

```
ursa(obj, attr, ...)
ursa(obj, attr, ...) <- value
```

Arguments

`obj`	Any numeric structure (scalar, matrix, array) for initializing. Object of class `ursaRaster` for extracting and assigning properties.
`attr`	Character. Name of property.

...	Arguments, which are passed for properties specification.
value	Value for property assignment.

Details

Initializing function ursa with missing argument attr is a wrapper for function as.ursa.

Matched pattern	*Replace method?*	*Description of property*	*Implementation*
"grid"	Yes	Raster grid (extent, projection, cellsize)	ursa_grid
"(proj|crs)"	Yes	Coordinate reference system	ursa_proj
"val"	Yes	Raster value in the internal storage format	ursa_value
"(colort|ct)"	Yes	Color table	ursa_colortable
"(categ|class)"	Yes	Names of categories	names(ursa_colortable(
"name"	Yes	Band names	names
"(nodata|ignorevalue|bg)"	Yes	Value, which is interpreted as NA.	ignorevalue
"^table$"	No	Frequency of unique values	as.table
"cell"	No	*Squared* cell size	with(ursa_grid(obj),sq
"^dim$"	No	Dimension of raster image	dim
"(extent|bbox)"	No	Spatial extent of raster image	with(ursa_grid(obj),c(
"(nrow|rows|lines)"	No	Number of rows of raster image	ursa_grid(obj)$rows
"(ncol|columns|samples)"	No	Number of columns of raster image	ursa_grid(obj)$columns
"con"	No	**str**ucture of connection	obj$con
"(info|meta(data)*)"	No	Metadata, brief info	ursa_info
"^file(name)*"	No	Connection name (filename)	objconfname

Argument ... is used to specify band index or band pattern in ursa(obj,"value",...)

Value

Inititalizing function ursa (missing attr) returns object of class ursaRaster.

Extract function ursa returns object of respective property.

Replace function ursa<- returns object

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

as.ursa

Examples

```
a1 <- ursa(volcano)
print(a1)
 ## to avoid over-timing during tests -- begin
   display(a1)
 ## to avoid over-timing during tests -- end
```

```
a2 <- ursa(volcano,flip=TRUE)
print(a2)
 ## to avoid over-timing during tests -- begin
   display(a2)
 ## to avoid over-timing during tests -- end

a3 <- ursa(volcano,permute=TRUE)
print(a3)
 ## to avoid over-timing during tests -- begin
   display(a3)
 ## to avoid over-timing during tests -- end

a4 <- ursa(volcano,flip=TRUE,permute=TRUE)
print(a4)
 ## to avoid over-timing during tests -- begin
   display(a4)
 ## to avoid over-timing during tests -- end

dima <- c(200,300,4)
b1 <- ursa(array(runif(prod(dima)),dim=dima))
print(b1)
display_brick(b1,scale=1,pal.rotate=0,pal.hue=0,decor=FALSE)
session_grid(NULL)

c1 <- ursa(seq(3))
print(c1)
c2 <- ursa(seq(3),bands=3)
print(c2)

c3 <- ursa(value=FALSE)
str(ursa(c3,"value"))

c4 <- ursa(bands=2,nodata=-99L)
print(c4)
print(ursa(c4,"nodata"))

c5 <- ursa(bandname=format(Sys.Date()+seq(7)-1,"%A"))
ursa(c5,"value") <- rev(seq(nband(c5)))
c5 <- colorize(c5)
ct <- ursa(c5,"colortable")
print(c5)

v <- ursa(c5[3:5],"value")
str(v)
v <- c(v)
str(v)
c6 <- ursa(v,colortable=ct)
print(c6)
print(ursa(c6,"colortable"))
```

`ursaConnection` *Connection of raster objects.*

Description

Class ursaConnection is a part of class ursaRaster. It defines storage of raster images and manipulations with reading and writing.

Usage

```
## S3 method for class 'ursaConnection'
print(x, ...)

## S3 method for class 'ursaConnection'
seek(con, where = NA, origin = "start", rw = "", ...)
```

Arguments

x	ursaConnection object in function print.
con	ursaConnection object in function seek.
where	Passed to seek for class connection.
origin	Passed to seek for class connection.
rw	Passed to seek for class connection.
...	print: Further arguments passed to generic functions print and str. seek: Further arguments passed to function seek for class connection.

Details

ursaConnection get item $con from ursaRaster object.

Functions print and is.con are for developers rather than users.

Non-public function .con.skeleton() is used to generate the blank ursaConnection object. This approach provides unified sequence of list's items:

Value

ursaConnection is a list. The most of names have a relation to specification of ENVI Header Files. Items:

driver	Character. Keyword of supported image formats. Allowed "ENVI" or "GDAL".
samples	Integer. Number of image columns (samples)
lines	Integer. Number of image rows (lines)
bands	Integer. Number of image bands (channels, layers)
datatype	Integer. Keyword for data type (4 - 32-bit floating point, 2 - 16-bit signed integer, *etc*)
interleave	Character "bsq", "bil", "bip". Data interleave - streams of bytes in storage.
byteorder	Integer, 0 or 1. The order of bytes. byteorder=0 less significant byte first, byteorder=1 most significant byte first
endian	Character. See \dQuote{endian} argument in readBin and writeBin

swap	Integer 0 or 1. Passed to C-funcions fread and fwrite
signed	Logical. Derived from $datatype
offset	Integer. Header offset in binary file. Default is 0.
wkt	Logical. In ENVI Header files wkt=TRUE forced to use "coordinate system string" field instead of "projection info" field
nodata	Numeric. Replacement NA values in the storage.
mode	Character. storage.mode of data
sizeof	Integer, positive. Size in bytes for stored values. Extracted from $datatype
indexC	Integer vector. Sample indices in spatial cropping.
indexR	Integer vector. Line indices in spatial cropping.
indexZ	Integer vector. Band indices
posC	Integer vector. Sample indices in partial reading.
posR	Integer vector. Line indices in partial reading.
posZ	Integer vector. Band indices in spatial crottping or partial reading.
fname	Character. File name. If driver=ENVI, then full path for ENVI binary file.
connection	Character. See connections
compress	Signed integer. 0L no compressing, -1L comressed file plus decompressed file,-2L decompressed file, 1L - file will be compressed.
seek	Logical. Does connection support seek?
handle	connections in fact

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

ursa(obj,"con")

Examples

```
session_grid(NULL)
print(methods(class="ursaConnection"))

a <- pixelsize()
write_envi(rep(a,5),"tmp1",compress=FALSE)
## change spatial domain for cropping example
g <- session_grid(regrid(lim=c(-1200000,-1400000,1600000,1800000)))
print(g)
b <- open_envi("tmp1")
d <- b[,30:70]
print(ursa(d[2:3],"con"))
close(b)
envi_remove("tmp1")
```

ursaCRS *Coordinate Reference System (CRS) for raster images.*

Description

Class ursaCRS is a part of class ursaGrid. It defines map projection.

Usage

```
## S3 method for class 'ursaCRS'
print(x, ...)
## S3 method for class 'ursaCRS'
str(object, ...)
```

Arguments

x	ursaCRS object in function print.
object	ursaCRS object in function str.
...	Further arguments passed to generic functions print, and str.

Value

Functions print information about CRS and return invisible NULL value.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy()
crs <- ursa_crs(a)
print(c('Is proj4string used?'=p4 <- isTRUE(getOption("ursaProj4Legacy"))))
print(crs)
str(crs)
op <- options(ursaProj4Legacy=!p4)
print(c('Is proj4string used?'=p4 <- isTRUE(getOption("ursaProj4Legacy"))))
session_grid(NULL)
a <- ursa_dummy()
crs <- ursa_crs(a)
print(crs)
str(crs)
options(op)
```

ursaGrid *Spatial parameters of raster images.*

Description

Class ursaGrid is a part of class ursaRaster. It defines spatial locations of image.

Usage

```
## S3 method for class 'ursaGrid'
print(x, ...)

## S3 method for class 'ursaGrid'
str(object, ...)

## S3 method for class 'ursaGrid'
dim(x)

## S3 method for class 'ursaGrid'
as.data.frame(x, row.names = NULL, optional = FALSE, ...)
```

Arguments

x	ursaGrid object in functions print, dim and as.data.frmame.
object	ursaGrid object in function str.
row.names	Ignored. Argument, which is passed to generic function as.data.frame.
optional	Ignored. Argument, which is passed to generic function as.data.frame.
...	Further arguments passed to generic functions as.data.frame, print, and str.

Details

The blank ursaGrid object is generated by calling of ursa_grid() without arguments. These approaches provide unified sequence of list's items:

```
List of 9
 $ columns: int NA
 $ rows   : int NA
 $ resx   : num NA
 $ resy   : num NA
 $ minx   : num NA
 $ maxx   : num NA
 $ miny   : num NA
 $ maxy   : num NA
 $ proj4  : chr ""
 - attr(*, "class")= chr "ursaGrid"
NULL
```

Value

Object of class `ursaGrid` is a list with items:

`columns`	Number of columns (samples)
`rows`	Number of rows (lines)
`resx`	Grid cell size by horizontal axis
`resy`	Grid cell size by vertical axis
`minx`	Left margin of boundary box
`maxx`	Right margin of boundary box
`miny`	Bottom margin of boundary box
`maxy`	Top margin of boundary box
`proj4`	PROJ.4 string

Function `dim` for object of class `ursaGrid` returns named vector of length 2: number of rows (`"lines"`) and number of elements in a row (`"samples"`)

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

`regrid`, `session_grid`

Examples

```
session_grid(NULL)
print(methods(class="ursaGrid"))

a <- pixelsize()
g <- ursa_grid(a)
print(is.ursa(a,"grid"))
print(is.ursa(g,"grid"))
print(g)
```

---

ursaProgressBar *Progress bar*

Description

Informative progress bars with dispaying elapsed and remained time.

Usage

```
ursaProgressBar(kind = c("tk", "txt"),title = .argv0(),
                label = "", min = 0, max = 1, initial = min, width = NA,
                style = 1, tail = FALSE, silent = FALSE)

setUrsaProgressBar(pb, value, title = NULL, label = NULL)

## S3 method for class 'ursaProgressBar'
close(con, ...)
```

Arguments

kind	Character. Type or progress bar. Valid values are "tk" to display progress bar in tcl/tk window and "txt" to display progress bar in terminal mode. Default is "tk".
style	See description for the same argument in txtProgressBar.
width	See description for the same argument in tkProgressBar.
title, label, min, max, initial, value, pb	See description for the same arguments in tkProgressBar and txtProgressBar.
con, ...	See description for the same arguments in close.
tail	Logical. Behaviour of progress bar appearing. If TRUE then progress bar will be used after progress step (e.g., at the end of routine). Default is FALSE (before progress step).
silent	Logical. If TRUE then progress bar will not appeared; it can be useful for conditional scripting. Default is FALSE.

Details

Wrapper to one of txtProgressBar, tkProgressBar .

Visualization of progress bar is updates each 0.5 seconds, it is effective for multiple short-term iterations.

Progress bars should be closed by calling of appropriate method of generic function close depending of class of reference progress bar.

Value

ursaProgressBar returns object of reference progress bar.

Note

Function name in style *camelCase* for consistence with other progress bar functions in R.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

txtProgressBar tkProgressBar

Examples

```
session_grid(NULL)
n1 <- 3
n2 <- 83
p <- 0.0011
#require(tcltk)
pb <- ursaProgressBar(min=0,max=n1,title="first",tail=TRUE)
for (i in seq(n1)) {
   pb2 <- ursaProgressBar(min=0,max=n2,title="second")
   for (i in seq(n2)) {
      setUrsaProgressBar(pb2)
      Sys.sleep(p)
   }
   close(pb2)
   setUrsaProgressBar(pb)
}
close(pb)
```

---

ursaRaster *Definition of* ursaRaster *class.*

Description

ursaRaster is S3 class for manipulation with georeferred raster images. See 'Value' *section*. is.ursa checks inhering to class ursaRaster

Usage

```
## S3 method for class 'ursaRaster'
print(x, digits = NA, grid = FALSE, raw = FALSE, caption = FALSE, ...)

## S3 method for class 'ursaRaster'
str(object,...)

is.ursa(obj, ref = NULL)
is_ursa(obj, ref = NULL)
```

Arguments

x, object	ursaRaster object.
obj	Any.
digits	Passed to format function

grid	Logical. If grid=TRUE then returns simplified metadata.
raw	Logical. If FALSE and values are categories, then attempting to restore numeric values from categorical names is before calculating of statistics. If TRUE then values for statistics are used as is. Default is FALSE.
caption	Logical of character. Print title or other identificational info. If logical and TRUE then print variable name or character representation of expression. If non-zero length character, then print this value. If FALSE (*default*) or zero-length character, then no header for printing.
...	Passed to format function
ref	Character or NULL. If character, then checking of ursaRaster sub-class(es):

Pattern	Description
NULL	ursaRaster
(raster|brick|ursa)	ursaRaster
grid	ursaGrid
(ct|color|table)	ursaColorTable
stack	ursaStack
con	ursaConnection
val	ursaNumeric OR ursaCategory
cat	ursaCategory

Details

is.ursa() is designed mainly for developers to check arguments' class in function's call. is_ursa is a synonym to is.ursa.
Stucture of ursaRaster class is generated by non-public .raster.skeleton() function.

Value

ursaRaster is R's S3 class. It is a list with items:

grid	Geospatial properties. ursaGrid object
con	Connection properties.ursaConnection object
value	2-dimensional numerical or integer matrix of classes ursaValue in *(spatial, temporal)* specification formed from *(samples*lines, bands)*. If data are not in memory, then NA.
dim	Dimension of $value. If bands are interpreted as observations in time, then it is *spatial* by *temporal* dimension of data. Even data are not in memory, dim is a dimension of whole data.
name	Band names
colortable	Color table. ursaColorTable object

is.ursa(x) returns TRUE, if class of x is ursaRaster

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
print(methods(class="ursaRaster"))

a <- pixelsize()
print(a)
print(a,grid=TRUE)
s <- substr(as.character(sessionInfo()),1,48)
b <- rep(a,length(s))
bandname(b) <- s
print(b)

require(datasets)
data(volcano)
print(is.ursa(a))
print(is.ursa(volcano))
print(is.ursa(as.ursa(volcano)))
```

`ursaStack` *List of raster images.*

Description

Functions to create list (layers) of multiband raster images (*stack* in the notation of **raster** package) and to coerce list of images to single multiband image (*brick* in the notation of **raster** package).

Usage

```
ursa_stack(...)

ursa_brick(obj)

ursa_apply(obj, FUN, ...)

## S3 method for class 'ursaRaster'
as.list(x, ...)

## S3 method for class 'ursaStack'
unlist(x, recursive, use.names)
```

Arguments

`obj`, `x`	Object of class `ursaRaster` or list of `ursaRaster` objects. In function `ursa_apply` argument "`X`", which is passed to function `lapply`.
`FUN`	Argument "`FUN`", which is passed to function `lapply`.
`recursive`	Not used. For consistency with generic function `unlist`.
`use.names`	Not used. For consistency with generic function `unlist`.

... Denending of functions:

ursa_stack, as.list
: List of ursaRaster objects

ursa_apply
: Arguments "...", which are passed to function lapply.

Details

as.list (of ursaRaster object(s)), ursa_stack create list of ursaRaster objects, where items of list are sinle-band images. If x is ursaRaster object, then list(x) create a list of length one, which item is multiband image.

unlist (for list of ursaRaster objects), ursa_brick create single multiband ursaRaster object. There is an alternative way for unlisting the list of ursaRaster: as.ursa.

Raster *stack* is a way to group bands, for example, by units (degree Celsium, meters).
Raster *brick* is a way to combine versalite images to the single multiband image, for example, for saving in file.

Value

ursa_stack, as.list return object of class ursaStack. It is a list, with class "ursaStack" attribute.

unlist (for list of ursaRaster objects), ursa_brick return object of class ursaRaster.

ursa_apply returns object of class ursaStack, if result is list of ursaRaster objects, otherwise returns general list.

Warning

There is no any verifications, that grids of ursaRaster objects are the same.

Note

Generic unlist(x) deals only with class of x, but doesn't take into account class of objects in list (e. g., x[[1]]). So, there is no effective way to use only list/unlist for ursaRaster objects to do a conversion between raster *brick* and *stack*. Generic unlist(x) deals only with class of x, but doesn't take into account class of objects in list (e. g., x[[1]]). So, there is no effective way to use only list/unlist for ursaRaster objects to do a conversion between raster *brick* and *stack*.

Author(s)

Nikita Platonov

References

https://CRAN.R-project.org/package=raster

See Also

lapply list unlist

c for ursaRaster objects.

Examples

```
session_grid(NULL)
a <- ursa_dummy(3)
print(a)
b1 <- ursa_stack(a[1:2],colorize(a[3],ramp=FALSE))
print(b1)
b2 <- as.list(a)
print(b2)
b3 <- list(a[1],a[2:3])
print(b3)
b31 <- lapply(b3,colorize,ramp=FALSE)
print(b31)
b32 <- ursa_apply(b3,colorize,ramp=FALSE,rev=TRUE)
print(b32)
s311 <- ursa_apply(b31,ursa_colortable)
print(s311)
s21 <- lapply(b2,global_mean)
print(s21)
s22 <- sapply(b2,global_mean)
print(s22)
s31 <- lapply(b3,global_mean)
print(s31)
s32 <- sapply(b3,global_mean)
print(s32)
c1 <- unlist(b1)
print(c1)
c2 <- unlist(b2)
print(c2)
c3 <- unlist(b3)
print(if (is.ursa(c3)) c3 else "broken object")
d3 <- as.ursa(b3)
print(if (is.ursa(d3)) d3 else "broken object")
```

---

ursaValue *Values of raster images.*

Description

Class ursaValue is a part of class ursaRaster. It contains values of image. In the case of numeric values, the exterior class is ursaNumeric. In the case of categorical values, the exterior class is ursaCategory.

Usage

```
## S3 method for class 'ursaCategory'
print(x, ...)

## S3 method for class 'ursaNumeric'
print(x, ...)

ursa_value(obj, band)
ursa_value(obj, band) <- value
```

Arguments

x	Object of the one of classes ursaNumeric or ursaCategory
...	Further arguments passed to generic functions print and str.
obj	Object of class ursaRaster
band	Optional. Vector of band numbers (positive integer) or band names (character).
value	Numeric or integer scalar, vector, or matrix. Coerced to dimenstion of ursaValue.

Details

Try to use high-level assignment using replacement [<- operator for class ursaRaster. However, if you don't get desired result, you can downgrade the level of your code.

Value

Object of class ursaNumeric is a numerical matrix. Object of class ursaCategory is an integer matrix. Dimensions of this matrix:

dim(...)[1]	Spatial domain; the length is muliplications of lines (rows) and samples (columns)
dim(...)[2]	Band or temporal domain; the length is number of bands

It is allowed to use scalar value NA in the case when values are not in memory. In this case the class is ursaValue.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

Extract [and replacement [<- methods for class ursaRaster

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/4))
a1 <- create_envi("exam1.envi",bandname=c("today","tomorrow"))
str(ursa_value(a1))
close(a1)
envi_remove("exam1")
a2 <- ursa_dummy(nband=4,min=1,max=99)
str(ursa_value(a2),digits=3)
a3 <- as.integer(a2)
str(ursa_value(a3))
str(ursa_value(a3,2))
print(ursa_value(a3))
print(a3)
ursa_value(a3,"Band 2") <- 199
ursa_value(a3)[,3] <- 299
a3[4] <- 399
print(a3)
ursa_value(a3[1:3]) <- ursa_value(a3[4])
print(a3)
ursa_value(a3[1:3]) <- -c(1:3)
print(a3)
```

`ursa_cache` *Cache management of ursa package*

Description

This help topic is about how cache is managed in the package.

Usage

```
ursa_cache()
```

Details

Users, who want to keep cache files between R sessions, should define option with name `ursaCacheDir` and value of the path for storage of cache files. This setting can be specified if `~/.Rprofile` file, or be in your code. If you specify permanent cache directory as sub-directory of `tempdir()` (see example), it will be removed after finishing of R session.

Value

NULL

Note

There is no neccessary to call this function. It just defines this help topic.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
 ## internet connection is required
options(ursaCacheDir=file.path(tempdir(),".ursaCacheDir"))
print(c(tempdir=tempdir(),ursaCacheDir=getOption("ursaCacheDir")))
glance("Mount Eden",place="park")
dir(getOption("ursaCacheDir"))
```

`ursa_crop` *Crop 'no data' margins.*

Description

Function `ursa_crop` makes such spatial subset of source raster image, where margins of 'no data' values are absent or have specified width.

Usage

```
ursa_crop(obj, condition, border = 0, expand = 1, resetGrid = TRUE, verbose = FALSE)
```

Arguments

`obj`	Object of class `ursaRaster`
`condition`	Object of class `ursaRaster` or `missing`. The condition for cutting. If 'missing' then condition is defined from `obj`.
`border`	Integer of length 1, 2 or 4. Desired margins for geographical subset. Units are cells (pixels).
`expand`	Numeric of length 1, 2 or 4. Desired boundary expansion for geographical subset. Units is ratio (relative to 1). Default is 1.
`resetGrid`	Logical. If `resetGrid=TRUE` then sessional grid parameters is established from grid parameters of created raster. If `resetGrid=FALSE` then sessional grid parameters keep without change. Defailu is `TRUE`.
`verbose`	Logical. `TRUE` provides some additional information on console.

Details

This function calls `regrid` with passing values of arguments `resetGrid` and `verbose` without changes.

Bordering (argument `border`) is applied before expansion (argument `expand`).

This function is an instrument for data compression for spatial matrices with wide margins of 'no data' value. It keeps spatial structure (pixel's neighborhood) in the internal data storage. Otherwise, `compress` reduces object size using spatial indexing with dropping of spatial structure.

Value

Object of class ursaRaster

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
'printCR' <- function(obj) print(with(ursa_grid(obj),c(c=columns,r=rows)))
g0 <- session_grid()
a <- pixelsize()
th <- with(ursa_grid(a),resx*resy*1e-6)
a0 <- a[a>th*0.9]
print(session_grid())
printCR(a0)
print(a0)
a1 <- ursa_crop(a0,resetGrid=TRUE)
print(session_grid())
printCR(a1)
print(a1)
a2 <- ursa_crop(a0,resetGrid=FALSE)
print(session_grid())
printCR(a2)
print(a2)
a3 <- a[a>=th*0.85 & a<=th*1.01]
b1 <- ursa_dummy(nband=3,min=0,max=255)
print(b1)
b2 <- ursa_crop(b1[a3>0],border=10)
print(b2)
printCR(b2)
b2[is.na(b2)] <- 255
display_rgb(b2)
b3 <- ursa_crop(b1,a3,border=0)
print(b3)
printCR(b3)
```

---

ursa_crs *Extract and assign projection of raster images.*

Description

Functions manipulate with $crs item of the ursaGrid object, which is embedded in the ursaRaster object (obj$grid$crs). Projection is specified in PROJ.4 notation.

Usage

```
ursa_crs(obj)
ursa_crs(obj, keepGrid = FALSE) <- value
```

Arguments

obj	ursaRaster object. It is allowed ursaGrid object for ursa_proj *(Extract)* function.
keepGrid	Logical. Should sessional grid be changed after assignment. Default is FALSE.
value	Character sting in PROJ.4 format.

Details

Boath *Extract* and *Replace* functions ursa_proj() and ursa_proj4() are synonyms for ursa_crs.

Value

Extract function ursa_crs returns character value of $grid$crs item of ursaRaster object.

Replace function ursa_crs<- returns ursaRaster with modified $grid$crs item.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

Examples

```
session_grid(NULL)
a <- ursa_dummy(nband=1)
print(ursa_crs(a))
p4s <- "+init=epsg:3576"
ursa_crs(a) <- p4s
print(ursa_crs(a))
fname <- tempfile()
write_envi(a,fname)
a2 <- read_envi(fname,resetGrid=TRUE)
print(ursa_crs(a2))
# try(print(rgdal::CRSargs(sp::CRS(p4s)))) ## 'rgdal' is retired
envi_remove(fname)
```

---

ursa_dummy *Generate raster image for examples.*

Description

ursa_dummy returns georeferenced raster image with required number of bands. The value of such image has no sence in reality, but are suitable for R's examples.

Usage

```
ursa_dummy(nband = 3L, minvalue = 0, maxvalue = 255, mul = 1, elements = 8L,
           bandname = NULL, nodata = TRUE, resetGrid=FALSE)
```

Arguments

nband	Positive integer. Number of bands. Default is 3L.
minvalue	Numeric of length 1. Minimal value for raster image. Default is 0.
maxvalue	Numeric of length 1. Maximal value for raster image. Default is 255.
mul	Positive numeric. The scaling of the existing session grid. Value 1 means the actual pixel size. Value <1 decreases image size by increasing cell size. Value >1 decreases image size by increasing cell size. Default is 1.
elements	Positive integer. Maximal dimension of matrix, which is proportional to session grid. If elements has small value then the resulting image is smooth, like low-resolution image. The elements has big value, then the resulting image is like white noise.
bandname	Character vector or NULL. Band names for created raster image. If NULL, then band names are generated autimatically. Default is NULL.
nodata	Numerical or logical. Set value, which is interpreted as 'no-data' flag. If logical and FALSE then no no-data flag is assigned. If logical and TRUE then value of no-data flag is generated automatically. If numeric, then no-data is assigned to value of this argument. Default is TRUE.
resetGrid	Logical. Whether the grid will be reset to default before raster generation? If FALSE then raster is generated in the sessional grid. If TRUE then default parameters are used for raster and session. Default is FALSE.

Details

Currently, the values are generated using runif.

The value mul<1 speeds up raster generation.

Value

Object of class ursaRaster

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
a1 <- as.integer(ursa_dummy(nband=1,mul=1/16,elements=1e3))  ## white noise
 ## to avoid over-time during example check -- begin
   display(a1,legend=NULL)
 ## to avoid over-time during example check -- end
a2 <- ursa_dummy()
print(a2)
display_brick(a2,decor=FALSE)
display_stack(a2,decor=FALSE)
display_rgb(a2,decor=FALSE)
```

ursa_grid *Extract and assign spatial parameters of raster images.*

Description

Raster image (ursaRaster) contains embedded spatial parameters (ursaGrid) in item $grid. These functions manipulate with item $grid.

Usage

```
ursa_grid(obj)
ursa_grid(obj) <- value

ursa_ncol(obj)
ursa_nrow(obj)
ursa_columns(obj)
ursa_rows(obj)
ursa_samples(obj)
ursa_lines(obj)

ursa_extent(obj)
ursa_bbox(obj)

consistent_grid(obj, ref, expand = 1, border = rep(0, 4), verbose = FALSE)
```

Arguments

obj	ursaRaster object. For ursa_grid function list of ursaRaster objects is allowed.
value	ursaGrid object.
ref	ursaGrid reference object.
expand	Podsitive numeric. Multiplier of boundary box.
border	integer of length 1 or 4. If length 4, then vector (bottom, left, top, right) in cells for extent expand. If length <4, then value is repeated for length 4. Passed to regrid().
verbose	Logical. Some output in console. Primarily for debug purposes.

Details

ursa_grid<- may used to minor corrections of spatial parameters. Howevert, it seems that this function is not claimed in practice.

ursa_ncol, ursa_columns, ursa_samples are synonyms for extracting number of columns/samples.

ursa_nrow, ursa_rows, ursa_lines are synonyms for extracting number of rows/lines.

ursa_extent, ursa_bbox, are synonyms for extracting boundary box (spatial extent).

consistent_grid trasforms dimension (ursa_nrow() by ursa_ncol()) obj-grid to dimension of ref-grid. This helpful for multipanel plotting if objects have different boundary boxes.

Value

`ursa_grid` return value of `$grid` item of `ursaRaster` object.

`ursa_grid<-` return `ursaRaster` with modified `$grid` item.

`ursa_ncol`, `ursa_columns`, `ursa_samples` return integer of length 1.

`ursa_nrow`, `ursa_rows`, `ursa_lines` return integer of length 1.

`ursa_extent`, `ursa_bbox` return numeric of length 4 (xmin, ymin, xmax, ymax).

`ursa_consistent` returns `ursaGrid` object.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
a <- pixelsize()
print(ursa_grid(a))
ursa_grid(a)$crs <- gsub("\\.0+","",ursa_grid(a)$crs)
print(ursa_grid(a))
```

---

ursa_info *Print metadata for raster image.*

Description

Function shows information about raster CRS, data type, storage mode, nodata value, structure of band names.

Usage

```
ursa_info(obj, detail = NA, ...)
```

Arguments

`obj`	`ursaRaster` object
`detail`	*Not used. Reserved for potential detail levels*
`...`	Arguments, which are passed to `str`.

Details

`ursa_info` generates a list and then shows structure of this list via function `str`.

Value

Object of *temporal* class `ursaMetadata` is a list with items:

`columns`	Number of columns (samples)
`rows`	Number of rows (lines)
`resx`	Grid cell size by horizontal axis
`resy`	Grid cell size by vertical axis
`minx`	Left margin of boundary box
`maxx`	Right margin of boundary box
`miny`	Bottom margin of boundary box
`maxy`	Top margin of boundary box
`proj4`	PROJ.4 string
`nodata`	*Optional*. Value, which is interpreted as `NA`
`datatype`	*Optional*. If data are on disk, then integer code of data type.
`interleave`	*Optional*. If data are on disk, then abbreviation of bands interleave.
`mode`	Character of length 2: `storage mode` and `class` of value. If data has not been read, then class is `"logical"`. If data is not in memory, then storage mode is `"raw"`.
`bandname`	Band names.
`colortable`	*Optional*. Structure of color table.

Function returns `NULL`.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

`str`
`print.ursaRaster`

Examples

```
session_grid(NULL)
a <- as.integer(round(ursa_dummy(nband=3)))

print(a) ## print data
ursa_info(a,digits=1) ## print metadata

fname <- tempfile()
write_envi(a,fname,compress=FALSE)
b1 <- open_envi(fname)
ursa_info(b1)
close(b1)
b2 <- read_envi(fname)
```

```
ursa_info(b2)

# print ENVI header
sapply(c(" -------------- begin --------------",readLines(paste0(fname,".hdr"))
        ," --------------- end ---------------"),message)

envi_remove(fname)
```

---

ursa_new *Create raster image in memory*

Description

ursa_new creates object of class ursaRaster in memory using session grid parameters or properties of input object (matrix or array). By option, band names and ignore values are specified.

Usage

```
ursa_new(...)
```

Arguments

...	Set of arguments, which are recognized via their names (using regular expressions) and classes: value Pattern is "(|^value)". Admissible classes are (matrix, array,numeric,logical. Values to fill image. Array or matrix defines raster grid. If value=FALSE (logical), then created raster image has no values. By default, value=NA, the created raster image is filled by blank values (NA). nband Positive integer. Number of bands. Default is 1L. bandname Character. Band names. Default is NULL. If specified, then nband is ignored, and the number of bands is equal to length of bandname character vector. ignorevalue Integer or numeric. Value in ENVI binary file, which is interpretted as NA in R. datatype Positive integer c(1L, 2L, 3L, 4L, 5L, 11L, 12L, 13L) or character. Data type (integer, floating-point) and byte length. See details for argument datatype of function create_envi. Required for writing raster to ENVI binart file. Optional for rasters in memory. Default is NA: data type is defined internally. colortable Object of class ursaColorTable. Color table for raster. Default is NULL: color table is absent permute Logical. Should dimensions of input matrix be changed. Default is FALSE. flip Logical. Vertical flip for input matrix. Default is FALSE: no flip. crs Character or object of class ursaGrid. The reference grid for raster's cells. Default is NULL: the grid is defined ether from matrix/array structure or from sessional parameters.

verb(ose)* Logical. Value TRUE may provide some additional information on console. Default is FALSE.

Details

ursa_new creates ursaRaster object in memory. To manipulate with raster chunks use the followed construction:

```
a <- create_envi(fname,...)
a[condition_1] <- value
print(a[condition_2]
...
close(a)
```

ursa_new is designed to create blank raster images. Use as.ursa for conversion R objects to ursaRaster.

Value

Object of class ursaRaster.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

as.ursa, create_envi.

Examples

```
session_grid(NULL)
a1 <- ursa_new(volcano)
print(a1)
 ## to avoid over-timing during tests -- begin
   display(a1)
 ## to avoid over-timing during tests -- end

a2 <- ursa_new(volcano,flip=TRUE)
print(a2)
 ## to avoid over-timing during tests -- begin
   display(a2)
 ## to avoid over-timing during tests -- end

a3 <- ursa_new(volcano,permute=TRUE)
print(a3)
 ## to avoid over-timing during tests -- begin
   display(a3)
 ## to avoid over-timing during tests -- end

dima <- c(200,300,4)
```

```
b1 <- as.ursa(array(runif(prod(dima)),dim=dima))
print(b1)
display_brick(b1,scale=1,pal=c("white","black"),decor=FALSE)

session_grid(NULL)

c1 <- ursa_new(seq(3))
print(c1)
c2 <- ursa_new(seq(3),bands=3)
print(c2)

c3 <- ursa_new(value=FALSE)
str(ursa_value(c3))

c4 <- ursa_new(bands=2,nodata=-99L)
print(c4)
print(ignorevalue(c4))

c5 <- ursa_new(bandname=format(Sys.Date()+seq(7)-1,"%A"))
ursa_value(c5) <- rev(seq(nband(c5)))
c5 <- colorize(c5)
ct <- ursa_colortable(c5)
print(c5)

v <- ursa_value(c5[3:5])
str(v)
v <- c(v)
str(v)
c6 <- ursa_new(v,colortable=ct)
print(c6)
print(ursa_colortable(c6))
```

`whiteboxing` *Wrapper to WhiteboxTools*

Description

Wrapper to tools from **"whitebox"** package to manipulate with `ursaRaster` objects

Usage

```
whiteboxing(tool_name, ...)
```

Arguments

`tool_name`	Either tool name of Whitebox or function name from **whitebox**.
`...`	List of parameters.

Details

Wrapper to function wbt_run_tool.

ursaRaster object foo can be passed via parameter input=foo instead of GeoTIFF file name.

Value

If argument output is missed or output=FALSE, then object of class ursaRaster. Otherwise, output GeoTIFF file name.

Note

Internally, for piping support, first character argument without *.tif suffix is interpreted as tool_name. First unnamed character argument with *.tif suffix or ursaRaster object is interpreted as input.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

WhiteboxTools **whitebox**

Examples

```
if ((requireNamespace("whitebox"))&&(isTRUE(whitebox::wbt_init()))) {
   dem <- whitebox::sample_dem_data()
   a1 <- c(DEM=read_gdal(dem))
   a2 <- whiteboxing("BreachDepressions",input=a1)
   b <- list(value=c(a1,a2),difference=c(diff=a1-a2))
   print(b)
   display(b,layout=c(2,NA),legend=list(list("first","left"),list("last","left")))
   if (getRversion()>="4.1.0") {
      a5 <- dem |>
         whiteboxing("feature_preserving_smoothing",filter=9) |>
         whiteboxing("breach_depressions") |>
         print()
   }
}
```

---

write_envi *Write raster image to ENVI .hdr Labelled Raster file.*

Description

write_envi writes in-memory object of class ursaRaster to disk in the ENVI .hdr Labelled Raster file format.

Usage

```
write_envi(obj, ...)
```

Arguments

obj	Object of class ursaRaster.
...	Arguments, which are passed to create_envi. Usually, only file name (character) is required. If missing, then occasional name is assigned.

Details

write_envi implements writing the whole ursaRaster object to disk. For multiple access to disk (by chunks), use followed construction:

```
a <- create_envi(fname)
a[condition_1] <- value1
a[condition_2] <- value2
...
close(a)
```

Value

Integer code of ENVI data type. See values of the "data type" field in description of the ENVI Header Format.

Author(s)

Nikita Platonov <platonov@sev-in.ru>

See Also

create_envi, *Replace* method [<- for ursaRaster object, close_envi (close for ursaRaster object).

write_gdal(...,driver="ENVI") uses GDAL (**rgdal**) for writing ursaRaster object to the ENVI .hdr Labelled Raster file.

Examples

```
session_grid(NULL)
dir.create(tmpWD <- file.path(tempdir(),"certain"))
wd <- setwd(tmpWD)
print(c('temp dir'=session_tempdir(),'working dir'=getwd()))
list1a <- envi_list(session_tempdir())
list1b <- envi_list()
fname <- tempfile(tmpdir=".")
a <- ursa_dummy()
bandname(a) <- c("first","second","third")
write_envi(a)
write_envi(a,fname)
list2a <- envi_list(session_tempdir())
```

```
list2b <- envi_list()
fname1 <- list2a[!(list2a %in% list1a)]
fname2 <- list2b[!(list2b %in% list1b)]
print(c('in temp dir'=fname1,'in working dir'=fname2))
a2 <- open_envi(fname1)
print(a2)
close(a2)
envi_remove(c(fname1,fname2))
setwd(wd)
```

`write_gdal` *Write raster image to GDAL file(s)*

Description

`write_gdal` writes in-memory object of class `ursaRaster` to disk using GDAL from **rgdal** package.

Usage

```
write_gdal(obj, ...)
ursa_write(obj, fname, ...)
```

Arguments

`obj`	Object of class `ursaRaster`.
`...`	Arguments, which are passed to `create_gdal`. Usually, only file name with extension (character) is required. If extension is ".envi", then GDAL driver "ENVI" is used. If extension is ".tif", then GDAL driver "GTiff" is used. If extension is ".img", then GDAL driver "HFA" is used. If extension is ".jpg" or "*.jpeg", then GDAL driver "JPEG" is used. If extension is ".bmp", then GDAL driver "BMP" is used. If extension is ".png", then GDAL driver "PNG" is used. Additionally, argument `driver` should be specified. If argument `...` is missing, then occasional name is assigned. For GDAL formats it is creation options `"-co"`, e. g., `compress="LZW",tiled="NO"` are interpeted as `-co "COMPRESS=LZW" -co "TILED=NO"`. For GDAL formats `options=` (named list `list(foo="bar1", foo2="bar2")`, named characters `c(foo="bar1", foo2="bar2")`, characters in format `"foo1=bar1 foo2=bar2"`) is interpeted as creation options (`-co`) explicitly. For GDAL formats `driver=` is interpeted as driver short name (`-fo`) explicitly.
`fname`	Character. File name with extension.

Details

`ursa_write` is simplified call of `write_gdal`.

`write_gdal` implements writing the whole `ursaRaster` object to disk. For multiple access to disk (by chunks), use followed *Replace* construction:

```
a <- create_gdal(fname)
a[condition_1] <- value1
a[condition_2] <- value2
...
close(a)
```

Value

Integer code of ENVI data type. See values of the "data type" field in description of the ENVI Header Format.

Author(s)

Nikita Platonov <platonov@sevin.ru>

See Also

create_gdal, *Replace* method [<- for ursaRaster object, close method for ursaRaster object.

write_envi

Examples

```
session_grid(NULL)
ftemp <- tempfile(pattern="",fileext="")
fpath <- dirname(ftemp)
fname <- basename(ftemp)
a <- round(ursa_dummy(1,min=0,max=255,nodata=NA))
write_envi(a,file.path(fpath,paste0(fname,"_1",".envi")))
write_gdal(a,file.path(fpath,paste0(fname,"_2")))
write_gdal(a,file.path(fpath,paste0(fname,"_3",".tif")))
write_gdal(a,file.path(fpath,paste0(fname,"_4")),driver="EHdr")
flist <- dir(path=fpath,pattern=fname,full.names=TRUE)
file.remove(flist)
blist <- basename(flist)
res <- NULL
for (i in seq(4))
   res <- c(res,paste(grep(paste0("_",i),blist,value=TRUE),collapse=" "))
print(res)
```

---

zonal_stat *Zonal statistics for raster maps*

Description

'Zonal' operator of map algebra. Applied to raster images.

Usage

```
zonal_stat(x, by, FUN, table = FALSE)

## S3 method for class 'ursaRaster'
aggregate(x, by, FUN, table = FALSE, ...)
```

Arguments

x	ursaRaster object. Image for analysis.
by	ursaRaster object. Image of grouping elements.
FUN	a function to compute the summary statistics which can be applied to all data subsets.
table	Logical. If table=TRUE then summary statistics for each group is returned. The statistics is defined by FUN. If stat=FALSE then result is presented as ursaRaster object.
...	Other arguments which passed to function aggregate of package **stats**

Details

zonal_stat is a wrapper of aggregate(x,by,FUN,table=FALSE,na.rm=TRUE)

You can use multichannel image (argument x) for analysis.

You can use multichannel raster image for group elements (argument by)

Value

If table=FALSE then ursaRaster object of summarized statistics.
If table=TRUE then data.frame.

Author(s)

Nikita Platonov <platonov@sevin.ru>

Examples

```
session_grid(NULL)
session_grid(regrid(mul=1/2))
a <- pixelsize()
val <- c(normal=a,half=a/2)
gr <- c(group=colorize(a,nbreak=1,lazyload=FALSE))#+0
print(as.table(gr))
##~ display(gr)
ra <- round(aggregate(val,gr,mean),4)
print(ra)
print(as.table(ra[1]))
print(as.table(ra[2]))
da <- aggregate(val,gr,table=TRUE,mean)
n <- aggregate(a,gr,table=TRUE,length)[,2,drop=FALSE]
```

```
da <- cbind(da,n=unname(n))
gr2 <- c(group2=colorize(a,nbreak=6,lazyload=FALSE))#+0
mgr <- list(gr,gr2)
da2 <- aggregate(val[1],mgr,table=TRUE,mean)
print(da2)
da3 <- aggregate(val,mgr,table=TRUE,mean)
print(da3)
ra3 <- aggregate(val,mgr,table=FALSE,mean) ## not implemented for rasters
print(ra3)
```

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