

Package ‘terra’

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Description Methods for spatial data analysis with raster and vector data. Raster methods allow for low-level data manipulation as well as high-level global, local, zonal, and focal computation. The predict and interpolate methods facilitate the use of regression type (interpolation, machine learning) models for spatial prediction, including with satellite remote sensing data. Processing of very large files is supported. See the manual and tutorials on <<https://rspatial.org/terra/>> to get started. 'terra' is very similar to the 'raster' package; but 'terra' can do more, is easier to use, and it is faster.

License GPL (>= 3)

URL <https://rspatial.org/terra/>

BugReports <https://github.com/rspatial/terra/issues/>

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terra-package	<i>The terra package</i>
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Description

terra provides methods to manipulate geographic (spatial) data in "raster" and "vector" form. Raster data divide space into rectangular cells (pixels) and they are commonly used to represent spatially continuous phenomena, such as elevation or the weather. Satellite images also have this data structure. In contrast, "vector" spatial data (points, lines, polygons) are typically used to represent discrete spatial entities, such as a road, country, or bus stop.

The package implements two main classes (R data types): `SpatRaster` and `SpatVector`. `SpatRaster` supports handling large raster files that cannot be loaded into memory; local, focal, zonal, and global raster operations; polygon, line and point to raster conversion; integration with modeling methods to make spatial predictions; and more. `SpatVector` supports all types of geometric operations such as intersections.

Additional classes include `SpatExtent`, which is used to define a spatial extent (bounding box); `SpatRasterDataset`, which represents a collection of sub-datasets for the same area. Each sub-dataset is a `SpatRaster` with possibly many layers, and may, for example, represent different weather

variables; and `SpatRasterCollection` and `SpatVectorCollection` that are vectors of `SpatRaster` or `SpatVector`.

These classes hold a C++ pointer to the data and they cannot be directly saved to a ".Rds" file or used in cluster computing. They cannot be recovered from a saved R session either. See [wrap](#) or [writeRaster](#) to work around that limitation.

The terra package is conceived as a replacement of the raster package. terra has a very similar, but simpler, interface, and it is faster than raster. At the bottom of this page there is a table that shows differences in the methods between the two packages.

Below is a list of some of the most important methods grouped by theme. Some of these may not have been implemented yet (they are not hyperlinked).

SpatRaster

I. Creating, combining and sub-setting SpatRaster objects

rast	Create a SpatRaster from scratch, file, or another object
c	Combine SpatRasters (multiple layers)
add<-	Add a SpatRaster to another one
subset or <code>[[</code> , or <code>\$</code>	Select layers of a SpatRaster
selectRange	Select cell values from different layers using an index layer

II. Changing the spatial extent and/or resolution of a SpatRaster

Also see the methods in section VIII

merge	Combine SpatRasters with different extents (but same origin and resolution)
mosaic	Combine SpatRasters with different extents using a function for overlapping cells
crop	Select a geographic subset of a SpatRaster
extend	Enlarge a SpatRaster
trim	Trim a SpatRaster by removing exterior rows and/or columns that only have NAs
aggregate	Combine cells of a SpatRaster to create larger cells
disagg	Subdivide cells
resample	Resample (warp) values to a SpatRaster with a different origin and/or resolution
project	Project (warp) values to a SpatRaster with a different coordinate reference system
shift	Adjust the location of SpatRaster
flip	Flip values horizontally or vertically
rotate	Rotate values around the date-line (for lon/lat data)
t	Transpose a SpatRaster

III. Local (cell based) computation

Apply-like methods:

<code>app</code>	Apply a function to all cells, across layers, typically to summarize (as in <code>base::apply</code>)
<code>tapp</code>	Apply a function to groups of layers (as in <code>base::tapply</code> and <code>stats::aggregate</code>)
<code>lapp</code>	Apply a function to using the layers of a <code>SpatRaster</code> as variables
<code>sapp</code>	Apply a function to each layer
<code>rapp</code>	Apply a function to a spatially variable range of layers

Arithmetic, logical, and standard math methods:

<code>Arith-methods</code>	Standard arithmetic methods (+, -, *, ^, %, %/, /)
<code>Compare-methods</code>	Comparison methods for <code>SpatRaster</code> (==, !=, >, <, <=, >=)
<code>Logic-methods</code>	Boolean methods (!, &,)
<code>Math-methods</code>	<code>abs</code> , <code>sign</code> , <code>sqrt</code> , <code>ceiling</code> , <code>floor</code> , <code>trunc</code> , <code>cummax</code> , <code>cummin</code> , <code>cumprod</code> , <code>cumsum</code> , <code>log</code> , <code>log10</code> , <code>log2</code> , <code>log1p</code> , <code>acos</code> , <code>acosh</code> , <code>asin</code> , <code>asinh</code> , <code>atan</code> , <code>atanh</code> , <code>exp</code> , <code>expm1</code> , <code>cos</code> , <code>cosh</code> , <code>sin</code> , <code>sinh</code> , <code>tan</code> , <code>tanh</code> , <code>round</code> , <code>signif</code>
<code>Summary-methods</code>	<code>mean</code> , <code>max</code> , <code>min</code> , <code>median</code> , <code>sum</code> , <code>range</code> , <code>prod</code> , <code>any</code> , <code>all</code> , <code>stdev</code> , <code>which.min</code> , <code>which.max</code>

Other methods:

<code>cellSize</code>	Compute the area of cells
<code>classify</code>	(Re-)classify values
<code>cover</code>	First layer covers second layer except where the first layer is NA
<code>init</code>	Initialize cells with new values
<code>mask</code>	Replace values in a <code>SpatRaster</code> based on values in another <code>SpatRaster</code>
<code>subst</code>	Substitute (replace) cell values
<code>which.lyr</code>	which is the first layer that is TRUE?

IV. Zonal and global computation

<code>expanse</code>	Compute the summed area of cells
<code>crosstab</code>	Cross-tabulate two <code>SpatRasters</code>
<code>freq</code>	Frequency table of <code>SpatRaster</code> cell values
<code>global</code>	Summarize <code>SpatRaster</code> cell values with a function
<code>quantile</code>	Quantiles
<code>stretch</code>	Stretch values
<code>scale</code>	Scale values
<code>summary</code>	Summary of the values of a <code>SpatRaster</code> (quantiles and mean)
<code>unique</code>	Get the unique values in a <code>SpatRaster</code>
<code>zonal</code>	Summarize a <code>SpatRaster</code> by zones in another <code>SpatRaster</code>

V. Focal and other spatial contextual computation

<code>focal</code>	Focal (neighborhood; moving window) functions
<code>adjacent</code>	Identify cells that are adjacent to a set of cells of a <code>SpatRaster</code>
<code>boundaries</code>	Detection of boundaries (edges)
<code>distance</code>	Shortest distance to a cell that is not NA or to or from a vector object
<code>direction</code>	Direction (azimuth) to or from cells that are not NA
<code>localFun</code>	Local association (using neighborhoods) functions
<code>patches</code>	Find patches (clumps)
<code>terrain</code>	Compute slope, aspect and other terrain characteristics from elevation data
<code>shade</code>	Compute hill shade from slope and aspect layers
<code>autocor</code>	Compute global or local spatial autocorrelation

VI. Model predictions

<code>predict</code>	Predict a non-spatial model to a <code>SpatRaster</code>
<code>interpolate</code>	Predict a spatial model to a <code>SpatRaster</code>

VII. Accessing cell values

Ap art from the function listed below, you can also use indexing with `[]` with cell numbers, and row and/or column numbers

<code>values</code>	cell values (fails with very large rasters)
<code>values<-</code>	Set new values to the cells of a <code>SpatRaster</code>
<code>setValues</code>	Set new values to the cells of a <code>SpatRaster</code>
<code>as.matrix</code>	Get cell values as a matrix
<code>as.array</code>	Get cell values as an array
<code>extract</code>	Extract cell values from a <code>SpatRaster</code> (e.g., by cell, coordinates, polygon)
<code>spatSample</code>	Regular or random sample
<code>minmax</code>	Get the minimum and maximum value of the cells of a <code>SpatRaster</code> (if known)
<code>setMinMax</code>	Compute the minimum and maximum value of a <code>SpatRaster</code> if these are not known
<code>extract</code>	spatial queries of a <code>SpatRaster</code> with a <code>SpatVector</code>

VIII. Getting and setting SpatRaster dimensions

Get or set basic parameters of SpatRasters. If there are values associated with a SpatRaster object (either in memory or via a link to a file) these are lost when you change the number of columns or rows or the resolution. This is not the case when the extent is changed (as the number of columns and rows will not be affected). Similarly, with `crs` you can set the coordinate reference system, but this does not transform the data (see [project](#) for that).

<code>ncol</code>	The number of columns
<code>nrow</code>	The number of rows
<code>ncell</code>	The number of cells (can not be set directly, only via <code>ncol</code> or <code>nrow</code>)
<code>res</code>	The resolution (x and y)
<code>nlyr</code>	Get or set the number of layers
<code>names</code>	Get or set the layer names
<code>xres</code>	The x resolution (can be set with <code>res</code>)
<code>yres</code>	The y resolution (can be set with <code>res</code>)
<code>xmin</code>	The minimum x coordinate (or longitude)
<code>xmax</code>	The maximum x coordinate (or longitude)
<code>ymin</code>	The minimum y coordinate (or latitude)
<code>ymax</code>	The maximum y coordinate (or latitude)
<code>ext</code>	Get or set the extent (minimum and maximum x and y coordinates ("bounding box"))
<code>origin</code>	The origin of a SpatRaster
<code>crs</code>	The coordinate reference system (map projection)
<code>is.lonlat</code>	Test if an object has (or may have) a longitude/latitude coordinate reference system
<code>sources</code>	Get the filename(s) to which a SpatRaster is linked
<code>inMemory</code>	Are the data sources in memory (or on disk)?
<code>compareGeom</code>	Compare the geometry of SpatRasters
<code>NAflag</code>	Set the NA value (for reading from a file with insufficient metadata)

IX. Computing row, column, cell numbers and coordinates

Cell numbers start at 1 in the upper-left corner. They increase within rows, from left to right, and then row by row from top to bottom. Likewise, row numbers start at 1 at the top of the raster, and column numbers start at 1 at the left side of the raster.

<code>xFromCol</code>	x-coordinates from column numbers
<code>yFromRow</code>	y-coordinates from row numbers
<code>xFromCell</code>	x-coordinates from row numbers
<code>yFromCell</code>	y-coordinates from cell numbers
<code>xyFromCell</code>	x and y coordinates from cell numbers
<code>colFromX</code>	Column numbers from x-coordinates (or longitude)
<code>rowFromY</code>	Row numbers from y-coordinates (or latitude)
<code>rowColFromCell</code>	Row and column numbers from cell numbers
<code>cellFromXY</code>	Cell numbers from x and y coordinates
<code>cellFromRowCol</code>	Cell numbers from row and column numbers
<code>cellFromRowColCombine</code>	Cell numbers from all combinations of row and column numbers
<code>cells</code>	Cell numbers from an SpatVector or SpatExtent

X. Writing SpatRaster files

Basic:

`writeRaster` Write all values of SpatRaster to disk. You can set the filetype, datatype, compression.
`writeCDF` Write SpatRaster data to a netCDF file

Advanced:

`writeStart` Open a file for writing
`writeValues` Write some values
`writeStop` Close the file after writing

XI. Miscellaneous SpatRaster methods

`terraOptions` Show, set, or get session options, mostly to control memory use and to set write options
`sources` Show the data sources of a SpatRaster
`tmpFiles` Show or remove temporary files
`mem_info` memory needs and availability
`readStart` Open file connections for efficient multi-chunk reading
`readStop` Close file connections
`inMemory` Are the cell values in memory?

SpatRasterDataSet

XII. SpatRasterDataset

A SpatRasterDataset contains SpatRaster objects that are sub-datasets for the same area. They all have the same extent and resolution.

`sds` Create a SpatRasterDataset from a file with subdatasets (ncdf or hdf) or from SpatRaster objects
`[or $` Extract a SpatRaster
`names` Get the names of the sub-datasets

SpatVector

XIII. Create SpatVector objects

<code>vect</code>	Create a SpatVector from a file (for example a "shapefile") or from another object
<code>rbind</code>	append SpatVectors of the same geometry type
<code>unique</code>	remove duplicates
<code>na.omit</code>	remove empty geometries and/or fields that are NA
<code>project</code>	Project a SpatVector to a different coordinate reference system
<code>writeVector</code>	Write SpatVector data to disk
<code>centroids</code>	Get the centroids of a SpatVector
<code>voronoi</code>	Voronoi diagram
<code>de-launy</code>	Delauny triangles
<code>convHull</code>	Compute the convex hull of a SpatVector
<code>fillHoles</code>	Remove or extract holes from polygons

XIV. Properties of SpatVector objects

<code>geom</code>	returns the geometries as matrix or WKT
<code>crds</code>	returns the coordinates as a matrix
<code>linearUnits</code>	returns the linear units of the crs (in meter)
<code>ncol</code>	The number of columns (of the attributes)
<code>nrow</code>	The number of rows (of the geometries and attributes)
<code>names</code>	Get or set the layer names
<code>ext</code>	Get the extent (minimum and maximum x and y coordinates ("bounding box"))
<code>crs</code>	The coordinate reference system (map projection)
<code>is.lonlat</code>	Test if an object has (or may have) a longitude/latitude coordinate reference system

XV. Geometric queries

<code>adjacent</code>	find adjacent polygons
<code>expanse</code>	computes the area covered by polygons
<code>nearby</code>	find nearby geometries
<code>nearest</code>	find the nearest geometries
<code>relate</code>	geometric relationships such as "intersects", "overlaps", and "touches"
<code>perim</code>	computes the length of the perimeter of polygons, and the length of lines

XVI. Geometric operations

<code>erase</code> or <code>"-"</code>	erase (parts of) geometries
<code>intersect</code> or <code>"*"</code>	intersect geometries
<code>union</code> or <code>"+"</code>	Merge geometries
<code>cover</code>	update polygons
<code>symdif</code>	symmetrical difference of two polygons
<code>aggregate</code>	dissolve smaller polygons into larger ones
<code>buffer</code>	buffer geometries
<code>disagg</code>	split multi-geometries into separate geometries
<code>crop</code>	clip geometries using a rectangle (<code>SpatExtent</code>) or <code>SpatVector</code>

XVII. SpatVector attributes

We use the term "attributes" for the tabular data (`data.frame`) associated with vector geometries.

<code>extract</code>	spatial queries between <code>SpatVector</code> and <code>SpatVector</code> (e.g. point in polygons)
<code>sel</code>	select - interactively select geometries
<code>click</code>	identify attributes by clicking on a map
<code>merge</code>	Join a table with a <code>SpatVector</code>
<code>as.data.frame</code>	get attributes as a <code>data.frame</code>
<code>values</code>	Get the attributes of a <code>SpatVector</code>
<code>values<-</code>	Set new attributes to the geometries of a <code>SpatRaster</code>

XVIII. Change geometries (for display, experimentation)

<code>shift</code>	change the position geometries by shifting their coordinates in horizontal and/or vertical direction
<code>spin</code>	rotate geometries around an origin
<code>rescale</code>	shrink (or expand) geometries, for example to make an inset map
<code>flip</code>	flip geometries vertically or horizontally
<code>t</code>	transpose geometries (switch x and y)

Spat* Collections

XIX. Collections

A `SpatRasterCollection` is a vector of `SpatRaster` objects. Unlike for a `SpatRasterDataset`, there the extent and resolution of the `SpatRasters` do not need to match each other. A `SpatVectorCollection` is a vector of `SpatVector` objects.

<code>svc</code>	create a <code>SpatRasterCollection</code> from a set of <code>SpatRaster</code> objects
<code>length</code>	how many <code>SpatRasters</code> does the <code>SpatRasterCollection</code> have?
<code>[</code>	extract a <code>SpatRaster</code>

SpatExtent

XX. SpatExtent

<code>ext</code>	Create a <code>SpatExtent</code> object. For example to <code>crop</code> a Spatial dataset
<code>intersect</code>	Intersect two <code>SpatExtent</code> objects, same as <code>-</code>
<code>union</code>	Combine two <code>SpatExtent</code> objects, same as <code>+</code>
<code>Math-methods</code>	round/floor/ceiling of a <code>SpatExtent</code>
<code>align</code>	Align a <code>SpatExtent</code> with a <code>SpatRaster</code>
<code>draw</code>	Create a <code>SpatExtent</code> by drawing it on top of a map (plot)

General methods

XXI. Data type conversion

You can coerce `SpatRasters` to `Raster*` objects after loading the `raster` package with `as(object, "Raster")`, or `raster(object)` or `brick(object)` or `stack(object)`

<code>rast</code>	<code>SpatRaster</code> from matrix and other objects
<code>vect</code>	<code>SpatVector</code> from <code>sf</code> or <code>Spatial*</code> vector data
<code>sf::st_as_sf</code>	<code>sf</code> object from <code>SpatVector</code>
<code>rasterize</code>	Rasterizing points, lines or polygons
<code>as.points</code>	Create points from a <code>SpatRaster</code> or <code>SpatVector</code>
<code>as.lines</code>	Create points from a <code>SpatRaster</code> or <code>SpatVector</code>
<code>as.polygons</code>	Create polygons from a <code>SpatRaster</code>
<code>as.contour</code>	Contour lines from a <code>SpatRaster</code>

XXII. Plotting**Maps:**

<code>plot</code>	Plot a <code>SpatRaster</code> or <code>SpatVector</code> . The main method to create a map
<code>points</code>	Add points to a map
<code>lines</code>	Add lines to a map
<code>polys</code>	Add polygons to a map
<code>text</code>	Add text (such as the values of a <code>SpatRaster</code> or <code>SpatVector</code>) to a map
<code>image</code>	Alternative to <code>plot</code> to make a map with a <code>SpatRaster</code>
<code>plotRGB</code>	Combine three layers (red, green, blue channels) into a single "real color" plot
<code>RGB2col</code>	Combine three layers (red, green, blue channels) into a single layer with a color-table
<code>dots</code>	Make a dot-density map
<code>cartogram</code>	Make a cartogram
<code>persp</code>	Perspective plot of a <code>SpatRaster</code>
<code>contour</code>	Contour plot or filled-contour plot of a <code>SpatRaster</code>
<code>inset</code>	Add a small inset (overview) map
<code>sbar</code>	Add a scalebar

Interacting with a map:

<code>zoom</code>	Zoom in to a part of a map by drawing a bounding box on it
<code>click</code>	Query values of <code>SpatRaster</code> or <code>SpatVector</code> by clicking on a map
<code>sel</code>	Select a spatial subset of a <code>SpatRaster</code> or <code>SpatVector</code> by drawing on a map
<code>draw</code>	Create a <code>SpatExtent</code> or <code>SpatVector</code> by drawing on a map

Other plots:

<code>plot</code>	x-y scatter plot of the values of (a sample of) the layers of two <code>SpatRaster</code> objects
<code>hist</code>	Histogram of <code>SpatRaster</code> values
<code>barplot</code>	Bar plot of a <code>SpatRaster</code>
<code>density</code>	Density plot of <code>SpatRaster</code> values
<code>pairs</code>	Pairs plot for layers in a <code>SpatRaster</code>
<code>boxplot</code>	Box plot of the values of a <code>SpatRaster</code>

Comparison with the raster package

XXIII. New method names

terra has a single class `SpatRaster` for which raster has three (`RasterLayer`, `RasterStack`, `RasterBrick`). Likewise there is a single class for vector data `SpatVector` that replaces six `Spatial*` classes. Most method names are the same, but note the following important differences in methods names with the raster package

raster package	terra package
raster, brick, stack	rast
rasterFromXYZ	rast(, type="xyz")
stack, addLayer (combining Raster* objects or files)	c
addLayer	add<-
area	cellSize
disaggregate	disagg
extent	ext
calc	app
overlay	lapp
stackApply	tapp
nlayers	nlyr
NValue	NAflag
stackSelect	selectRange
reclassify, subs, cut	classify
cellStats	global
projectRaster	project
dropLayer	subset
isLonLat, isGlobalLonLat, couldBeLonLat	is.lonlat
shapefile	vect
gridDistance, distanceFromPoints	distance
drawExtent, drawPoly, drawLine	draw
compareRaster	compareGeom
sampleRandom, sampleRegular	spatSample
rasterToPoints	as.points
rasterToPolygons	as.polygons
cellFromLine, cellFromPolygon, cellsFromExtent	cells
layerize	segregate
clump	patches

XXIV. Changed behavior

Also note that even if function names are the same in terra and raster, their output can be different. In most cases this was done to get more consistency in the returned values (and thus fewer errors in the downstream code that uses them). In other cases it simply seemed better. Here are some examples:

as.polygons	By default, terra returns dissolved polygons
extract	By default, terra returns a matrix, with the first column the sequential ID of the vectors. raster returns a list (for lines or polygons) or a matrix (for points, but without the ID column. You can use <code>list=TRUE</code> to get the results as a list
values	terra always returns a matrix. raster returns a vector for a RasterLayer
Summary-methods	With raster, <code>mean(x, y)</code> and <code>mean(stack(x, y))</code> return the same result, a single layer with the mean of all cell values. This is also what terra returns with <code>mean(c(x, y))</code> , but with <code>mean(x, y)</code> the parallel mean is returned – that is, the computation is done layer-wise, and the number of layers in the output is the same as that of <code>x</code> and <code>y</code> (or the larger of the two if they are not the same). This affects all summary functions (<code>sum</code> , <code>mean</code> , <code>median</code> , <code>which.min</code> , <code>which.max</code> , <code>min</code> , <code>max</code> ,

prod, any, all, stdev), except range, which is not implemented for this case (you can use min and max instead)

Author

Except where indicated otherwise, the methods and functions in this package were written by Robert Hijmans. The configuration scripts were written by Roger Bivand for `rgdal` and `sf`. Some of the C++ code for GDAL/GEOS was adapted from code by Edzer Pebesma for `sf`. The progress bar code is by Karl Forner (`RcppProgress`). Jeroen Ooms provided the compiled GDAL and GEOS libraries for installation on windows

Acknowledgments

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activeCat

Active category

Description

Get or set the active category of a multi-categorical `SpatRaster` layer

Usage

```
## S4 method for signature 'SpatRaster'
activeCat(x, layer=1)
## S4 replacement method for signature 'SpatRaster'
activeCat(x, layer=1)<-value
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>layer</code>	positive integer, the layer number or name
<code>value</code>	a <code>data.frame</code> (ID, category) or vector with category names

Value

integer

See Also

[catalyze](#), [cats](#)

Examples

```
set.seed(0)
r <- rast(nrows=10, ncols=10)
values(r) <- sample(3, ncell(r), replace=TRUE) + 10
d <- data.frame(id=11:13, cover=c("forest", "water", "urban"), letters=letters[1:3], value=10:12)
levels(r) <- d

activeCat(r)
activeCat(r) <- 3
activeCat(r)
```

add

Add (in place) a SpatRaster to another SpatRaster object

Description

Add (in place) a SpatRaster to another SpatRaster object. Comparable with [c](#), but without copying the object.

Usage

```
## S4 replacement method for signature 'SpatRaster,SpatRaster'
add(x)<-value
```

Arguments

x	SpatRaster
value	SpatRaster

Value

SpatRaster

See Also

[c](#)

Examples

```
r <- rast(nrows=5, ncols=9, vals=1:45)
x <- c(r, r*2)
add(x) <- r*3
x
```

adjacent	<i>Adjacent cells</i>
----------	-----------------------

Description

Identify cells that are adjacent to a set of raster cells. Or identify adjacent polygons

Usage

```
## S4 method for signature 'SpatRaster'
adjacent(x, cells, directions="rook", pairs=FALSE, include=FALSE)

## S4 method for signature 'SpatVector'
adjacent(x, type="rook", pairs=TRUE, symmetrical=FALSE)
```

Arguments

x	SpatRaster
cells	vector of cell numbers for which adjacent cells should be found. Cell numbers start with 1 in the upper-left corner and increase from left to right and from top to bottom
directions	character or matrix to indicated the directions in which cells are considered connected. The following character values are allowed: "rook" or "4" for the horizontal and vertical neighbors; "bishop" to get the diagonal neighbors; "queen" or "8" to get the vertical, horizontal and diagonal neighbors; or "16" for knight and one-cell queen move neighbors. If directions is a matrix it should have odd dimensions and have logical (or 0, 1) values
pairs	logical. If TRUE, a two-column matrix of pairs of adjacent cells is returned. If x is a SpatRaster and pairs is FALSE, an n*m matrix is returned where the number of rows n is length(cells) and the number of columns m is the number of neighbors requested with directions
include	logical. Should the focal cells be included in the result? They are always included if pairs=TRUE
type	character. One of "rook", "queen", "touches", or "intersects". "queen" and "touches" are synonyms. "rook" exclude polygons that touch at a single node only. "intersects" includes polygons that touch or overlap
symmetrical	logical. If TRUE, an adjacent pair is only included once. For example, if polygon 1 is adjacent to polygon 3, the implied adjacency between 3 and 1 is not reported

Value

matrix

See Also

[relate](#), [nearby](#)

Examples

```

r <- rast(nrows=10, ncols=10)
adjacent(r, cells=c(1, 5, 55), directions="queen")
r <- rast(nrows=10, ncols=10, crs="+proj=utm +zone=1 +datum=WGS84")
adjacent(r, cells=11, directions="rook")

#same as
rk <- matrix(c(0,1,0,1,0,1,0,1,0), 3, 3)
adjacent(r, cells=11, directions=rk)

## note that with global lat/lon data the E and W connect
r <- rast(nrows=10, ncols=10, crs="+proj=longlat +datum=WGS84")
adjacent(r, cells=11, directions="rook")

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
a <- adjacent(v, symmetrical=TRUE)
head(a)

```

aggregate

Aggregate raster or vector data

Description

Aggregate a `SpatRaster` to create a new `SpatRaster` with a lower resolution (larger cells). Aggregation groups rectangular areas to create larger cells. The value for the resulting cells is computed with a user-specified function.

Or aggregate ("dissolve") a `SpatVector`.

Usage

```

## S4 method for signature 'SpatRaster'
aggregate(x, fact=2, fun="mean", ..., cores=1, filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatVector'
aggregate(x, by=NULL, dissolve=TRUE, fun="mean", ...)

```

Arguments

x	<code>SpatRaster</code>
fact	positive integer. Aggregation factor expressed as number of cells in each direction (horizontally and vertically). Or two integers (horizontal and vertical aggregation factor) or three integers (when also aggregating over layers)
fun	function used to aggregate values. Either an actual function, or for the following, their name: "mean", "max", "min", "median", "sum" and "modal"
...	additional arguments passed to fun, such as <code>na.rm=TRUE</code>

cores	positive integer. If cores > 1, a 'parallel' package cluster with that many cores is created. Ignored for C++ level implemented functions "mean", "max", "min", "median", "sum" and "modal"
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster
by	character. The variable used to aggregate the geometries
dissolve	logical. Should borders between aggregated geometries be dissolved?

Details

Aggregation starts at the upper-left end of a `SpatRaster`. If a division of the number of columns or rows with `factor` does not return an integer, the extent of the resulting `SpatRaster` will be somewhat larger than that of the original `SpatRaster`. For example, if an input `SpatRaster` has 100 columns, and `fact=12`, the output `SpatRaster` will have 9 columns and the maximum x coordinate of the output `SpatRaster` is also adjusted.

The function `fun` should take multiple numbers, and return a single number. For example `mean`, `modal`, `min` or `max`.

It should also accept a `na.rm` argument (or ignore it as one of the 'dots' arguments).

Value

`SpatRaster`

See Also

[disagg](#) to disaggregate

Examples

```
r <- rast()
# aggregated SpatRaster, no values
ra <- aggregate(r, fact=10)

values(r) <- runif(ncell(r))
# aggregated raster, max of the values
ra <- aggregate(r, fact=10, fun=max)

# multiple layers
s <- c(r, r*2)
x <- aggregate(s, 2)

## SpatVector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
va <- aggregate(v, "ID_1")

plot(va, "NAME_1", lwd=5, plg=list(x="topright"), mar=rep(2,4))
```

```
lines(v, lwd=3, col="light gray")
lines(va)
text(v, "ID_1", halo=TRUE)
```

align

Align a SpatExtent

Description

Align an SpatExtent with a SpatRaster. This can be useful to create a new SpatRaster with the same origin and resolution as an existing SpatRaster. Do not use this to force data to match that really does not match (use e.g. [resample](#) or (dis)aggregate for this).

It is also possible to align a SpatExtent to a clean divisor.

Usage

```
## S4 method for signature 'SpatExtent,SpatRaster'
align(x, y, snap="near")
```

```
## S4 method for signature 'SpatExtent,numeric'
align(x, y)
```

Arguments

x	SpatExtent
y	SpatRaster or numeric
snap	Character. One of "near", "in", or "out", to determine in which direction the extent should be aligned. To the nearest border, inwards or outwards

Value

SpatExtent

See Also

[ext](#), [draw](#)

Examples

```
r <- rast()
e <- ext(-10.1, 9.9, -20.1, 19.9)
ea <- align(e, r)
e
ext(r)
ea

align(e, 0.5)
```

animate *Animate a SpatRaster*

Description

Animate (sequentially plot) the layers of a SpatRaster to create a movie

Usage

```
## S4 method for signature 'SpatRaster'  
animate(x, pause=0.25, main, range, maxcell=50000, n=1, ...)
```

Arguments

x	SpatRaster
pause	numeric. How long should be the pause be between layers?
main	title for each layer. If not supplied the z-value is used if available. Otherwise the names are used.
range	numeric vector of length 2. Range of values to plot
maxcell	integer > 0. Maximum number of cells to use for the plot. If maxcell < ncell(x), spatSample(type="regular") is used before plotting
n	integer > 0. Number of loops
...	Additional arguments passed to plot

Value

None

See Also

[plot](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))  
animate(s, n=1)
```

app

*Apply a function to the cells of a SpatRaster***Description**

Apply a function to the values of each cell of a SpatRaster. Similar to [apply](#) – think of each layer in a SpatRaster as a column (or row) in a matrix.

This is generally used to summarize the values of multiple layers into one layer; but this is not required.

app calls function fun with the raster data as first argument. Depending on the function supplied, the raster data is represented as either a matrix in which each layer is a column, or a vector representing a cell. The function should return a vector or matrix that is divisible by ncell(x). Thus, both "sum" and "rowSums" can be used, but "colSums" cannot be used.

You can also apply a function fun across datasets by layer of a SpatRasterDataset. In that case, summarization is across SpatRasters, not across layers.

Usage

```
## S4 method for signature 'SpatRaster'
app(x, fun, ..., cores=1, filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRasterDataset'
app(x, fun, ..., cores=1, filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster or SpatRasterDataset
fun	a function that operates on a vector or matrix. This can be a function that is defined in base-R or in a package, or a function you write yourself (see examples). Functions that return complex output (e.g. a list) may need to be wrapped in your own function to simplify the output to a vector or matrix. The following functions have been re-implemented in C++ for speed: "sum", "mean", "median", "modal", "which", "which.min", "which.max", "min", "max", "prod", "any", "all", "sd", "std", "first". To use the base-R function for say, "min", you could use something like fun=function(i) min(i) or the equivalent fun = \ (i) min(i)
...	additional arguments for fun. These are typically numerical constants. They should <i>never</i> be another SpatRaster
cores	positive integer. If cores > 1, a 'parallel' package cluster with that many cores is created and used. Ignored for functions that are implemented by terra in C++ (see under fun)
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Details

To speed things up, parallelization is supported, but this is often not helpful, and it may actually be slower. There is only a speed gain if you have many cores (> 8) and/or a very complex (slow) function fun. If you write fun yourself, consider supplying a `cppFunction` made with the `Rcpp` package instead (or go have a cup of tea while the computer works for you).

Value

`SpatRaster`

See Also

[lapp](#), [tapp](#), [math](#)

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
x <- c(r, sqrt(r), r+50)
s <- app(x, fun=sum)
s
# for a few generic functions like
# "sum", "mean", and "max" you can also do
sum(x)

## SpatRasterDataset
sd <- sds(x, x*2, x/3)
a <- app(sd, max)
a
# same as
max(x, x*2, x/3)

## also works for a single layer
f <- function(i) (i+1) * 2 * i + sqrt(i)
s <- app(r, f)
# same as above, but that is not memory-safe
# and has no filename argument
s <- f(r)

## Not run:
#### multiple cores
test0 <- app(x, sqrt)
test1 <- app(x, sqrt, cores=2)

testfun <- function(i) { 2 * sqrt(i) }
test2 <- app(x, fun=testfun, cores =2)

## this fails because testfun is not exported to the nodes
# test3 <- app(x, fun=function(i) testfun(i), cores=2)
## to export it, add it as argument to fun
test3 <- app(x, fun=function(i, ff) ff(i), cores =3, ff=testfun)
```



```
## End(Not run)
```

as.character	<i>Create a text representation of (the skeleton of) an object</i>
--------------	--

Description

Create a text representation of (the skeleton of) an object

Usage

```
## S4 method for signature 'SpatExtent'  
as.character(x)  
  
## S4 method for signature 'SpatRaster'  
as.character(x)
```

Arguments

x	SpatRaster
---	------------

Value

character

Examples

```
r <- rast()  
ext(r)  
ext(c(0, 20, 0, 20))
```

as.data.frame	<i>SpatRaster or SpatVector to data.frame</i>
---------------	---

Description

Coerce a SpatRaster or SpatVector to a data.frame or coerce a SpatVector to a list

Usage

```
## S4 method for signature 'SpatVector'
as.data.frame(x, geom=NULL)

## S4 method for signature 'SpatRaster'
as.data.frame(x, xy=FALSE, cells=FALSE, na.rm=TRUE)

## S4 method for signature 'SpatVector'
as.list(x, geom=NULL)

## S4 method for signature 'SpatRaster'
as.list(x)
```

Arguments

x	SpatVector
geom	character or NULL. If not NULL, either "WKT" or "HEX", to get the geometry included in Well-Known-Text or hexadecimal notation
xy	logical. If TRUE, the coordinates of each raster cell are included
cells	logical. If TRUE, the cell numbers of each raster cell are included
na.rm	logical. If TRUE, cells that have a NA value in at least one layer are removed

Value

data.frame

See Also

see [coerce](#) for as.data.frame with a SpatRaster; and [geom](#) to only extract the geometry of a SpatVector

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
as.data.frame(v)
as.list(v)
```

as.raster

Coerce to a "raster" object

Description

Implementation of the generic [as.raster](#) function to create a "raster" (small r) object. Such objects can be used for plotting with the [rasterImage](#) function. NOT TO BE CONFUSED with the Raster* (big R) objects defined by the 'raster' package!

Usage

```
## S4 method for signature 'SpatRaster'
as.raster(x, maxcell=500000, col)
```

Arguments

x	SpatRaster
maxcell	positive integer. Maximum number of cells to use for the plot
col	vector of colors. Default is col=rev(terrain.colors(255)))

Value

'raster' object

Examples

```
r <- rast(ncols=3, nrows=3)
values(r) <- 1:ncell(r)
as.raster(r)
```

as.spatvector

Conversion to a SpatVector, or to another SpatVector type

Description

Conversion of a SpatRaster or SpatExtent to a SpatVector of points, lines, or polygons;
And conversion of a SpatVector to a another SpatVector type.

Usage

```
## S4 method for signature 'SpatRaster'
as.polygons(x, trunc=TRUE, dissolve=TRUE, values=TRUE, na.rm=TRUE, extent=FALSE)
```

```
## S4 method for signature 'SpatRaster'
as.lines(x)
```

```
## S4 method for signature 'SpatRaster'
as.points(x, values=TRUE, na.rm=TRUE)
```

```
## S4 method for signature 'SpatVector'
as.polygons(x)
```

```
## S4 method for signature 'SpatVector'
as.lines(x)
```

```
## S4 method for signature 'SpatVector'
```

```

as.points(x, multi=FALSE, skiplast=TRUE)

## S4 method for signature 'SpatExtent'
as.polygons(x, crs="")

## S4 method for signature 'SpatExtent'
as.lines(x, crs="")

## S4 method for signature 'SpatExtent'
as.points(x, crs="")

```

Arguments

x	SpatRaster or SpatVector
trunc	logical; truncate values to integers. Cells with the same value are merged. Therefore, if trunc=FALSE the object returned can be very large
dissolve	logical; combine cells with the same values? If TRUE only the first layer in x is processed
values	logical; include cell values as attributes? If FALSE the cells are not dissolved and the object returned can be very large
multi	logical. If TRUE a multipoint geometry is returned
skiplast	logical. If TRUE the last point of a polygon (which is the same as the first point) is not included
extent	logical. If TRUE, a polygon for the extent of the SpatRaster is returned. It has vertices for each grid cell, not just the four corners of the raster. This can be useful for more precise projection. In other cases it is better to do as.polygons(ext(x)) to get a much smaller object returned that covers the same extent
na.rm	logical. If TRUE cells that are NA are ignored
crs	character. The coordinate reference system (see crs)

Value

SpatVector

Examples

```

r <- rast(ncols=2, nrows=2)
values(r) <- 1:ncell(r)

as.points(r)
as.lines(ext(r), crs=crs(r))

if (gdal() >= "3.0.0") {
  p <- as.polygons(r)
  p
  as.lines(p)
  as.points(p)
}

```

atan2	<i>Two argument arc-tangent</i>
-------	---------------------------------

Description

For `SpatRasters` `x` and `y`, `atan2(y, x)` returns the angle in radians for the tangent `y/x`, handling the case when `x` is zero. See [Trig](#)

See [Math-methods](#) for other trigonometric and mathematical functions that can be used with `SpatRasters`.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
atan2(y, x)
```

Arguments

<code>y</code>	<code>SpatRaster</code>
<code>x</code>	<code>SpatRaster</code>

See Also

[Math-methods](#)

Examples

```
r1 <- rast(nrows=10, ncols=10)
r2 <- rast(nrows=10, ncols=10)
values(r1) <- (runif(ncell(r1))-0.5) * 10
values(r2) <- (runif(ncell(r1))-0.5) * 10
atan2(r1, r2)
```

autocorrelation	<i>Spatial autocorrelation</i>
-----------------	--------------------------------

Description

Compute spatial autocorrelation for a numeric vector or a `SpatRaster`. You can compute standard (global) Moran's I or Geary's C, or local indicators of spatial autocorrelation (Anselin, 1995).

Usage

```
## S4 method for signature 'numeric'
autocor(x, w, method="moran")

## S4 method for signature 'SpatRaster'
autocor(x, w=matrix(c(1,1,1,1,0,1,1,1,1),3), method="moran", global=TRUE)
```

Arguments

x	numeric or SpatRaster
w	Spatial weights defined by or a rectangular matrix. For a SpatRaster this matrix must the sides must have an odd length (3, 5, ...)
global	logical. If TRUE global autocorrelation is computed instead of local autocorrelation
method	character. If x is numeric or SpatRaster: "moran" for Moran's I and "geary" for Geary's C. If x is numeric also: "Gi", "Gi*" (the Getis-Ord statistics), locmor (local Moran's I) and "mean" (local mean)

Details

The default setting uses a 3x3 neighborhood to compute "Queen's case" indices. You can use a filter (weights matrix) to do other things, such as "Rook's case", or different lags.

Value

numeric or SpatRaster

References

- Moran, P.A.P., 1950. Notes on continuous stochastic phenomena. *Biometrika* 37:17-23
- Geary, R.C., 1954. The contiguity ratio and statistical mapping. *The Incorporated Statistician* 5: 115-145
- Anselin, L., 1995. Local indicators of spatial association-LISA. *Geographical Analysis* 27:93-115
https://en.wikipedia.org/wiki/Indicators_of_spatial_association

See Also

The spdep package for additional and more general approaches for computing spatial autocorrelation

Examples

```
### raster
r <- rast(nrows=10, ncols=10, xmin=0)
values(r) <- 1:ncell(r)

autocor(r)

# rook's case neighbors
f <- matrix(c(0,1,0,1,0,1,0,1,0), nrow=3)
autocor(r, f)

# local
rc <- autocor(r, w=f, global=FALSE)

### numeric (for vector data)
```

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
w <- relate(v, relation="touches")

# global
autocor(v$AREA, w)

# local
v$Gi <- autocor(v$AREA, w, "Gi")
plot(v, "Gi")
```

barplot

Bar plot of a SpatRaster

Description

Create a barplot of the values of a the first layer of a SpatRaster. For large datasets a regular sample with a size of approximately maxcells is used.

Usage

```
## S4 method for signature 'SpatRaster'
barplot(height, maxcell=1000000, digits=0, breaks=NULL, col, ...)
```

Arguments

height	SpatRaster
maxcell	integer. To regularly subsample very large datasets
digits	integer used to determine how to round the values before tabulating. Set to NULL or to a large number if you do not want any rounding
breaks	breaks used to group the data as in cut
col	a color generating function such as rainbow (the default), or a vector of colors
...	additional arguments for plotting as in barplot

Value

A numeric vector (or matrix, when beside = TRUE) of the coordinates of the bar midpoints, useful for adding to the graph. See [barplot](#)

See Also

[hist](#), [boxplot](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
barplot(r, digits=-1, las=2, ylab="Frequency")

op <- par(no.readonly = TRUE)
par(mai = c(1, 2, .5, .5))
barplot(r, breaks=10, col=c("red", "blue"), horiz=TRUE, digits=NULL, las=1)
par(op)
```

boundaries

Detect boundaries (edges)

Description

Detect boundaries (edges). Boundaries are cells that have more than one class in the 4 or 8 cells surrounding it, or, if `classes=FALSE`, cells with values and cells with NA.

Usage

```
## S4 method for signature 'SpatRaster'
boundaries(x, classes=FALSE, inner=TRUE,
           directions=8, falseval=0, filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>inner</code>	logical. If TRUE, "inner" boundaries are returned, else "outer" boundaries are returned
<code>classes</code>	character. Logical. If TRUE all different values are (after rounding) distinguished, as well as NA. If FALSE (the default) only edges between NA and non-NA cells are considered
<code>directions</code>	integer. Which cells are considered adjacent? Should be 8 (Queen's case) or 4 (Rook's case)
<code>falseval</code>	numeric. The value to use for cells that are not a boundary and not NA
<code>filename</code>	character. Output filename
<code>...</code>	options for writing files as in writeRaster

Value

SpatRaster. Cell values are either 1 (a border) or 0 (not a border), or NA

See Also

[focal](#), [patches](#)

Examples

```
r <- rast(nrows=18, ncols=36, xmin=0)
r[150:250] <- 1
r[251:450] <- 2
bi <- boundaries(r)
bo <- boundaries(r, inner=FALSE)
bc <- boundaries(r, classes=TRUE)
#plot(bc)
```

boxplot

*Box plot of SpatRaster data***Description**

Box plot of layers in a SpatRaster

Usage

```
## S4 method for signature 'SpatRaster'
boxplot(x, y=NULL, maxcell=100000, ...)
```

Arguments

x	SpatRaster
y	NULL or a SpatRaster. If x is a SpatRaster it used to group the values of x by "zone"
maxcell	Integer. Number of cells to sample from datasets
...	additional arguments passed to <code>graphics::boxplot</code>

Value

boxplot returns a list (invisibly) that can be used with `bxp`

See Also

[pairs](#), [hist](#)

Examples

```
r1 <- r2 <- r3 <- rast(ncols=10, nrows=10)
set.seed(409)
values(r1) <- rnorm(ncell(r1), 100, 40)
values(r2) <- rnorm(ncell(r1), 80, 10)
values(r3) <- rnorm(ncell(r1), 120, 30)
s <- c(r1, r2, r3)
names(s) <- c("Apple", "Pear", "Cherry")

boxplot(s, notch=TRUE, col=c("red", "blue", "orange"), main="Box plot", ylab="random", las=1)
```

```

op <- par(no.readonly = TRUE)
par(mar=c(4,6,2,2))
boxplot(s, horizontal=TRUE, col="lightskyblue", axes=FALSE)
axis(1)
axis(2, at=0:3, labels=c("", names(s)), las=1, cex.axis=.9, lty=0)
par(op)

## boxplot with 2 layers
v <- vect(system.file("ex/lux.shp", package="terra"))
r <- rast(system.file("ex/elev.tif", package="terra"))
#y <- rasterize(v, r, "NAME_2")
#b <- boxplot(r, y)
#bxp(b)

```

buffer

Create a buffer around vector objects or raster patches

Description

Calculate a buffer around all cells that are not NA in a `SpatRaster`, or around the geometries of a `SpatVector` (currently only implemented for points)

Note that the distance unit of the buffer width parameter is meters if the CRS is (+proj=longlat), and in map units (typically also meters) if not.

Usage

```

## S4 method for signature 'SpatRaster'
buffer(x, width, filename="", ...)

## S4 method for signature 'SpatVector'
buffer(x, width, quadsegs=10)

```

Arguments

x	SpatRaster or SpatVector
width	numeric. Unit is meter if x has a longitude/latitude CRS, or mapunits in other cases. Should be > 0 for SpatRaster
filename	character. Output filename
...	additional arguments for writing files as in writeRaster
quadsegs	positive integer. Number of line segments to use to draw a quart circle

Value

SpatRaster

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

```

r <- rast(ncols=36, nrows=18)
v <- rep(NA, ncell(r))
v[500] <- 1
values(r) <- v
b <- buffer(r, width=5000000)
plot(b)

v <- vect(rbind(c(10,10), c(0,60)), crs="+proj=merc")
b <- buffer(v, 20)
plot(b)
points(v)

crs(v) <- "+proj=longlat"
b <- buffer(v, 1500000)
plot(b)
points(v)

```

c

*Combine SpatRaster or SpatVector objects***Description**

With `c` you can:

- Combine `SpatRaster` objects. They must have the same extent and resolution. Also see [add<-](#)
- Add a `SpatRaster` to a `SpatRasterDataset`
- Add `SpatVector` objects to a new or existing `SpatVectorCollection`

To append `SpatVectors`, use `rbind`.

Usage

```

## S4 method for signature 'SpatRaster'
c(x, ...)

## S4 method for signature 'SpatRasterDataset'
c(x, ...)

## S4 method for signature 'SpatVector'
c(x, ...)

## S4 method for signature 'SpatVectorCollection'
c(x, ...)

```

Arguments

x SpatRaster, SpatVector, SpatRasterDataset or SpatVectorCollection
 ... as for x (you can only combine raster with raster data and vector with vector data)

Value

Same class as x

See Also

[add<-](#)

Examples

```
r <- rast(nrows=5, ncols=9)
values(r) <- 1:ncell(r)
x <- c(r, r*2, r*3)
```

cartogram

Cartogram

Description

Make a cartogram, that is, a map where the area of polygons is made proportional to another variable. This can be a good way to map raw count data (e.g. votes).

Usage

```
## S4 method for signature 'SpatVector'
cartogram(x, var, type)
```

Arguments

x SpatVector
 var character. A variable name in x
 type character. Cartogram type, only "nc" (non-contiguous) is currently supported

Value

SpatVector

See Also

[plot](#), [rescale](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v$value <- 1:12
p <- cartogram(v, "value", "nc")
plot(v, col="light gray", border="gray")
lines(p, col="red", lwd=2)
```

catalyze

Factors to numeric

Description

Change a categorical layer into one or more numerical layers. With `as.numeric` you can transfer the active category values to cell values in a non categorical `SpatRaster`. `catalyze` transfers all categories to new layers.

Usage

```
## S4 method for signature 'SpatRaster'
as.numeric(x, index=NULL, filename="", ...)

## S4 method for signature 'SpatRaster'
catalyze(x, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>index</code>	positive integer, indicating the column in <code>data.frame</code> value to be used as the category, skipping the first column with the ID. If <code>NULL</code> the active category is used
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[activeCat](#), [cats](#)

Examples

```

set.seed(0)
r <- rast(nrows=10, ncols=10)
values(r) <- sample(3, ncell(r), replace=TRUE) + 10
d <- data.frame(id=11:13, cover=c("forest", "water", "urban"), letters=letters[1:3], value=10:12)
levels(r) <- d
catalyze(r)

activeCat(r) <- 3
as.numeric(r)

```

cells

Get cell numbers

Description

Get the cell numbers covered by a `SpatVector` or `SpatExtent`. Or that match values in a vector; or all non NA values.

Usage

```

## S4 method for signature 'SpatRaster,missing'
cells(x, y)

## S4 method for signature 'SpatRaster,numeric'
cells(x, y)

## S4 method for signature 'SpatRaster,SpatVector'
cells(x, y, method="simple", weights=FALSE, exact=FALSE, touches=is.lines(y))

## S4 method for signature 'SpatRaster,SpatExtent'
cells(x, y)

```

Arguments

x	<code>SpatRaster</code>
y	<code>SpatVector</code> , <code>SpatExtent</code> , 2-column matrix representing points, numeric representing values to match, or missing
method	character. Method for getting cell numbers for points. The default is "simple", the alternative is "bilinear". If it is "bilinear", the four nearest cells and their weights are returned
weights	logical. If TRUE and y has polygons, the approximate fraction of each cell that is covered is returned as well
exact	logical. If TRUE and y has polygons, the exact fraction of each cell that is covered is returned as well
touches	logical. If TRUE, values for all cells touched by lines or polygons are extracted, not just those on the line render path, or whose center point is within the polygon. Not relevant for points

Value

numeric vector or matrix

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
r[c(1:25, 31:100)] <- NA
r <- ifel(r > 28, r + 10, r)

# all cell numbers of cells that are not NA
cells(r)

# cell numbers that match values
x <- cells(r, c(28,38))
x$lyr.1

# cells for points
m <- cbind(x=c(0,10,-30), y=c(40,-10,20))
cellFromXY(r, m)

v <- vect(m)
cells(r, v)
cells(r, v, method="bilinear")

# cells for polygons
#f <- system.file("ex/lux.shp", package="terra")
#v <- vect(f)
#r <- rast(v)
#cv <- cells(r, v)
```

cellSize

Area covered by each raster cell

Description

Compute the area covered by individual raster cells. Computing the surface area of raster cells is particularly relevant for longitude/latitude rasters.

Note that for both angular (longitude/latitude) and for planar (projected) coordinate reference systems raster cells sizes are generally not constant, unless you are using an equal-area crs.

For planar CRSs, the area is therefore not computed based on the linear units of the coordinate reference system, but on the *actual* area, correcting for distortion. If you do not want that, you can instead use `init(x,prod(res(x)))`

Usage

```
## S4 method for signature 'SpatRaster'
cellSize(x, mask=TRUE, unit="m", transform=TRUE, filename="", ...)
```

Arguments

x	SpatRaster
mask	logical. If TRUE, cells that are NA in x are also NA in the output
unit	character. One of "m", "km", or "ha"
transform	logical. If TRUE, planar CRS data are transformed to lon/lat for accuracy
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

numeric (area)

See Also

[expand](#)

Examples

```
# SpatRaster
r <- rast(nrows=18, ncols=36)
v <- 1:ncell(r)
v[200:400] <- NA
values(r) <- v

# size of each raster cell
a <- cellSize(r)

# illustration of distortion
r <- rast(ncols=90, nrows=45, ymin=-80, ymax=80)
m <- project(r, "+proj=merc")

bad <- init(m, prod(res(m)) / 1000000, names="naive")
good <- cellSize(m, unit="km", names="corrected")
plot(c(good, bad), nc=1, mar=c(2,2,1,6))
```

centroids

Get centroids

Description

Get the centroids for the polygons of a SpatVector

Usage

```
## S4 method for signature 'SpatVector'
centroids(x)
```


Arguments

x SpatVector

Value

SpatVector of points

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
x <- centroids(v)
```

clamp *Clamp values*

Description

Clamp values to a minimum and maximum value. That is, all values below a lower threshold value and above the upper threshold value become either NA, or, if values=TRUE, become the threshold value

Usage

```
## S4 method for signature 'SpatRaster'
clamp(x, lower=-Inf, upper=Inf, values=TRUE, filename="", ...)

## S4 method for signature 'numeric'
clamp(x, lower=-Inf, upper=Inf, values=TRUE, ...)
```

Arguments

x SpatRaster
lower numeric. lowest value
upper numeric. highest value
values logical. If FALSE values outside the clamping range become NA, if TRUE, they get the extreme values
filename character. Output filename
... additional arguments for writing files as in [writeRaster](#)

Value

SpatRaster

See Also

[classify](#)

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
rc <- clamp(r, 25, 75)
rc
```

 classify

Classify (or reclassify) cell values

Description

Classify values of a SpatRaster. The function (re-)classifies groups of values to other values.

The classification is done based on the argument `rc1`. You can classify ranges by specifying a three-column matrix "from-to-becomes" or change specific values by using a two-column matrix "is-becomes". You can also supply a vector with "cuts" or the "number of cuts".

With "from-to-becomes" or "is-becomes" classification is done in the row order of the matrix. Thus, if there are overlapping ranges or values, the first time a number is within a range determines the reclassification value.

With "cuts" the values are sorted, so that the order in which they are provided does not matter.

Usage

```
## S4 method for signature 'SpatRaster'
classify(x, rc1, include.lowest=FALSE, right=TRUE,
         othersNA=FALSE, filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>rc1</code>	matrix for classification. This matrix must have 1, 2 or 3 columns. If there are three columns, the first two columns are "from" "to" of the input values, and the third column "becomes" has the new value for that range. The two column matrix ("is", "becomes") can be useful for re-classifying integer values. In that case, the <code>right</code> argument is automatically set to <code>NA</code> . A single column matrix (or a vector) is interpreted as a set of cuts if there is more than one value. In that case the values are classified based on their location inbetween the cut-values. If a single number is provided, that is used to make that number of cuts, at equal intervals between the lowest and highest values of the SpatRaster.
<code>include.lowest</code>	logical, indicating if a value equal to the lowest value in <code>rc1</code> (or highest value in the second column, for <code>right=FALSE</code>) should be included.
<code>right</code>	logical, indicating if the intervals should be closed on the right (and open on the left) or vice versa. The default is <code>TRUE</code> . A special case is to use <code>right=NA</code> . In this case both the left and right intervals are open

othersNA	logical. If TRUE, values that are not matched become NA. If FALSE, they retain their original value.
filename	character. Output filename
...	Additional arguments for writing files as in writeRaster

Value

SpatRaster

NoteFor model-based classification see [predict](#)**See Also**[subst](#) for simpler from-to replacement**Examples**

```
r <- rast(ncols=10, nrows=10)
values(r) <- (0:99)/99

## from-to-becomes
# classify the values into three groups
# all values >= 0 and <= 0.25 become 1, etc.
m <- c(0, 0.25, 1,
       0.25, 0.5, 2,
       0.5, 1, 3)
rclmat <- matrix(m, ncol=3, byrow=TRUE)
rc1 <- classify(r, rclmat, include.lowest=TRUE)

## cuts
# equivalent to the above
rc2 <- classify(r, c(0, 0.25, 0.5, 1), include.lowest=TRUE)

## is-becomes
x <- round(r*3)
unique(x)
# replace 0 with NA
y <- classify(x, cbind(0, NA))
unique(y)

# multiple replacements
m <- rbind(c(2, 200), c(3, 300))
m

rcx1 <- classify(x, m)
unique(rcx1)

rcx2 <- classify(x, m, othersNA=TRUE)
unique(rcx2)
```

click *Query by clicking on a map*

Description

Click on a map (plot) to get the coordinates or the values of a `SpatRaster` or `SpatVector` at that location. For a `SpatRaster` you can also get the coordinates and cell number of the location.

Usage

```
## S4 method for signature 'SpatRaster'  
click(x, n=10, id=FALSE, xy=FALSE, cell=FALSE, type="p", show=TRUE, ...)  
  
## S4 method for signature 'SpatVector'  
click(x, n=10, id=FALSE, xy=FALSE, type="p", show=TRUE, ...)  
  
## S4 method for signature 'missing'  
click(x, n=10, id=FALSE, type="p", show=TRUE, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code> , or missing
<code>n</code>	number of clicks on the plot (map)
<code>id</code>	logical. If TRUE, a numeric ID is shown on the map that corresponds to the row number of the output
<code>xy</code>	logical. If TRUE, xy coordinates are included in the output
<code>cell</code>	logical. If TRUE, cell numbers are included in the output
<code>type</code>	one of "n", "p", "l" or "o". If "p" or "o" the points are plotted; if "l" or "o" they are joined by lines. See <code>?locator</code>
<code>show</code>	logical. Print the values after each click?
<code>...</code>	additional graphics parameters used if <code>type != "n"</code> for plotting the locations. See <code>?locator</code>

Value

The value(s) of `x` at the point(s) clicked on (or touched by the box drawn).

Note

The plot only provides the coordinates for a spatial query, the values are read from the `SpatRaster` that is passed as an argument. Thus you can extract values from an object that has not been plotted, as long as it spatially overlaps with the extent of the plot.

Unless the process is terminated prematurely values at at most `n` positions are determined. The identification process can be terminated by hitting `Esc`, or by clicking the right mouse button and selecting "Stop" from the menu, or from the "Stop" menu on the graphics window.

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

```
## Not run:
r <-rast(system.file("ex/elev.tif", package="terra"))
plot(r)
click(r, n=1)
## now click on the plot (map)

## End(Not run)
```

coerce

*Coercion of a SpatRaster to other object types***Description**

Coercion to other object types

Usage

```
## S4 method for signature 'SpatRaster'
as.vector(x, mode='any')

## S4 method for signature 'SpatRaster'
as.matrix(x, wide=FALSE)

## S4 method for signature 'SpatRaster'
as.array(x)
```

Arguments

x	SpatRaster or SpatVector
mode	this argument is ignored
wide	logical. If FALSE each layer in the SpatRaster becomes a column in the matrix and each cell in the SpatRaster becomes a row. If TRUE each row in the SpatRaster becomes a row in the matrix and each column in the SpatRaster becomes a column in the matrix

Value

vector, matrix, array

See Also[as.data.frame](#) and [as.polygons](#)

Examples

```
r <- rast(ncols=2, nrows=2)
values(r) <- 1:ncell(r)

as.vector(r)
as.matrix(r)
as.matrix(r, wide=TRUE)
as.data.frame(r, xy=TRUE)
as.array(r)
```

 colors

Color table

Description

Get or set color table(s) associated with a SpatRaster. Color tables are used for associating colors with values, for use in mapping (plot).

Usage

```
## S4 method for signature 'SpatRaster'
coltab(x)

## S4 replacement method for signature 'SpatRaster'
coltab(x, layer=1)<-value
```

Arguments

x	SpatRaster
layer	positive integer, the layer number or name
value	a vector of colors; or a three (red,green,blue) or four (alpha) column data.frame with no more than 256 rows; or NULL to remove the color table

Value

data.frame

Examples

```
r <- rast(ncols=3, nrows=2, vals=0:5)
coltb <- data.frame(t(col2rgb(rainbow(6, end=.9), alpha=TRUE)))
coltb

plot(r)
coltab(r) <- coltb
plot(r)
```

```
tb <- coltab(r)
class(tb)
dim(tb[[1]])
```

compareGeom

Compare geometries of SpatRasters

Description

Evaluate whether two SpatRaster objects have the same extent, number of rows and columns, projection, resolution, and origin (or a subset of these comparisons).

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
compareGeom(x, y, ..., lyrs=FALSE, crs=TRUE, warncrs=FALSE, ext=TRUE,
rowcol=TRUE, res=FALSE, stopOnError=TRUE)
```

Arguments

x	SpatRaster
y	SpatRaster
...	Additional SpatRasters
lyrs	logical. If TRUE, the number of layers is compared
crs	logical. If TRUE, coordinate reference systems are compared
warncrs	logical. If TRUE, a warning is given if the crs is different (instead of an error)
ext	logical. If TRUE, bounding boxes are compared
rowcol	logical. If TRUE, number of rows and columns of the objects are compared
res	logical. If TRUE, resolutions are compared (redundant when checking extent and rowcol)
stopOnError	logical. If TRUE, code execution stops if raster do not match

Examples

```
r1 <- rast()
r2 <- rast()
r3 <- rast()
compareGeom(r1, r2, r3)
nrow(r3) <- 10

## Not run:
compareGeom(r1, r3)

## End(Not run)
```

 contour

Contour plot

Description

Contour lines of a SpatRaster. Use `add=TRUE` to add the lines to the current plot. See [contour](#) for details.

if `filled=TRUE`, a new filled contour plot is made. See [filled.contour](#) for details.

`as.contour` returns the contour lines as a SpatVector.

Usage

```
## S4 method for signature 'SpatRaster'
contour(x, maxcells=100000, filled=FALSE, ...)
```

```
## S4 method for signature 'SpatRaster'
as.contour(x, maxcells=100000, ...)
```

Arguments

<code>x</code>	SpatRaster. Only the first layer is used
<code>maxcells</code>	maximum number of pixels used to create the contours
<code>filled</code>	logical. If TRUE, a filled.contour plot is made
<code>...</code>	any argument that can be passed to contour or filled.contour (graphics package)

See Also

[plot](#)

Examples

```
r <- rast(system.file("ex/elev.tif", package="terra"))
plot(r)
contour(r, add=TRUE)

v <- as.contour(r)
plot(r)
lines(v)

contour(r, filled=TRUE, nlevels=5)

## if you want a SpatVector with contour lines
#template <- disagg(rast(r), 10)
#rr <- resample(r, template)
#rr <- floor(rr/100) * 100
#v <- as.polygons(rr)
```



```
#plot(v, 1, col=terrain.colors(7))
```

convHull	<i>Convex hull and minimal rotated rectangle</i>
----------	--

Description

Get the convex hull or the minimal rotated rectangle of a `SpatVector`

Usage

```
## S4 method for signature 'SpatVector'  
convHull(x, by="")  
  
## S4 method for signature 'SpatVector'  
minRect(x, by="")
```

Arguments

x	<code>SpatVector</code>
by	character (variable name), to make convex hulls by group

Value

`SpatVector`

Examples

```
p <- vect(system.file("ex/lux.shp", package="terra"))  
h <- convHull(p)  
  
hh <- convHull(p, "NAME_1")  
rr <- minRect(p, "NAME_1")  
  
plot(rr, lwd=5, border="gray")  
plot(hh, "NAME_1", col=rainbow(10, alpha=.5), lwd=3, add=TRUE, plg=list(x="topright"))  
lines(aggregate(p, "NAME_1"), col="blue", lty=2, lwd=2)
```

copy

Deep copy

Description

Make a deep copy of a `SpatRaster` or `SpatVector`. This is occasionally useful when wanting to use a replacement function in a shallow copy. That is a copy that was created like this: `x <-y`. If you use a replacement function to change an object, its shallow copies also change.

Usage

```
## S4 method for signature 'SpatRaster'  
copy(x)
```

```
## S4 method for signature 'SpatVector'  
copy(x)
```

Arguments

x `SpatRaster` or `SpatVector`

Value

Same as x

Examples

```
r <- rast(ncols=10, nrows=10, nl=3)  
tm <- as.Date("2001-05-03") + 1:3  
time(r) <- tm  
time(r)  
x <- r  
time(x) <- tm + 365  
time(x)  
time(r)  
  
y <- copy(r)  
time(y) <- tm - 365  
time(y)  
time(r)  
  
# or make a new object like this  
z <- rast(r)  
time(z) <- tm  
time(z)  
time(r)
```

cover	<i>Replace values with values from another object</i>
-------	---

Description

Replace NA or other values in `SpatRaster` `x` with the values of `SpatRaster` `y`

For polygons: areas of `x` that overlap with `y` are replaced by `y` or, if `identity=TRUE` intersected with `y`.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
cover(x, y, values=NA, filename="", ...)
```

```
## S4 method for signature 'SpatVector,SpatVector'
cover(x, y, identity=FALSE)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>y</code>	Same as <code>x</code>
<code>values</code>	numeric. The cell values in <code>x</code> to be replaced by the values in <code>y</code>
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster
<code>identity</code>	logical. If <code>TRUE</code> overlapping areas are intersected rather than replaced

Value

`SpatRaster`

Examples

```
r1 <- r2 <- rast(ncols=36, nrows=18)
values(r1) <- 1:ncell(r1)
values(r2) <- runif(ncell(r2))
r2 <- classify(r2, cbind(-Inf, 0.5, NA))
r3 <- cover(r2, r1)
```

```
p <- vect(system.file("ex/lux.shp", package="terra"))
e <- as.polygons(ext(6, 6.4, 49.75, 50))
values(e) <- data.frame(y=10)
#cv <- cover(p, e)
#plot(cv, col=rainbow(12))
#ci <- cover(p, e, identity=TRUE)
#lines(e, lwd=3)
```

```
#plot(ci, col=rainbow(12))
#lines(e, lwd=3)
```

crds

Get the coordinates of SpatVector geometries or SpatRaster cells

Description

Get the coordinates of a SpatVector or SpatRaster cells. A matrix or data.frame of the x (longitude) and y (latitude) coordinates is returned.

Usage

```
## S4 method for signature 'SpatVector'
crds(x, df=FALSE)
```

```
## S4 method for signature 'SpatRaster'
crds(x, df=FALSE, na.rm=TRUE)
```

Arguments

x	SpatRaster or SpatVector
df	logical. If TRUE a data.frame is returned in stead of a matrix
na.rm	logical. If TRUE cells that are NA are excluded

Value

matrix or data.frame

See Also

[geom](#) returns the complete structure of SpatVector geometries. For SpatRaster see [codexyFromCell](#)

Examples

```
x1 <- rbind(c(-175,-20), c(-140,55), c(10, 0), c(-140,-60))
x2 <- rbind(c(-125,0), c(0,60), c(40,5), c(15,-45))
x3 <- rbind(c(-10,0), c(140,60), c(160,0), c(140,-55))
x4 <- rbind(c(80,0), c(105,13), c(120,2), c(105,-13))
z <- rbind(cbind(object=1, part=1, x1), cbind(object=2, part=1, x2),
          cbind(object=3, part=1, x3), cbind(object=3, part=2, x4))
colnames(z)[3:4] <- c('x', 'y')
z <- cbind(z, hole=0)
z[z[, "object"]==3 & z[, "part"]==2, "hole"] <- 1

p <- vect(z, "polygons")
```

```
crds(p)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
g <- crds(v)
head(g)
```

crop

Cut out a geographic subset

Description

Cut out a part of a `SpatRaster` with a `SpatExtent`, or another object from which an extent can be obtained. With a `SpatRaster` you can only extract rectangular areas, but see [mask](#) for setting cell values within `SpatRaster` to NA.

You can crop a `SpatVector` with a rectangle, or with another vector (if these are not polygons, the minimum convex hull is used). Unlike with [intersect](#) the geometries and attributes of `y` are not transferred to the output.

Usage

```
## S4 method for signature 'SpatRaster'
crop(x, y, snap="near", filename="", ...)

## S4 method for signature 'SpatVector'
crop(x, y)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>y</code>	<code>SpatRaster</code> , <code>SpatVector</code> , <code>SpatExtent</code> or other object that has a <code>SpatExtent</code> (<code>ext</code> returns a <code>SpatExtent</code>)
<code>snap</code>	character. One of "near", "in", or "out"
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[intersect](#)

Examples

```

r <- rast(xmin=0, xmax=10, ymin=0, ymax=10, nrows=25, ncols=25)
values(r) <- 1:ncell(r)
e <- ext(-5, 5, -5, 5)
rc <- crop(r, e)

# vector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
e <- ext(6.15, 6.3, 49.7, 49.8)
x <- crop(v, e)
#plot(x, "NAME_1")

```

crosstab

Cross-tabulate

Description

Cross-tabulate the layers of a SpatRaster to create a contingency table.

Usage

```

## S4 method for signature 'SpatRaster,missing'
crosstab(x, digits=0, long=FALSE, useNA=FALSE)

```

Arguments

x	SpatRaster
digits	integer. The number of digits for rounding the values before cross-tabulation
long	logical. If TRUE the results are returned in 'long' format data.frame instead of a table
useNA	logical, indicating if the table should includes counts of NA values

Value

A table or data.frame

See Also

[freq](#), [zonal](#)

Examples

```

r <- s <- rast(nc=5, nr=5)
set.seed(1)
values(r) <- runif(ncell(r)) * 2
values(s) <- runif(ncell(r)) * 3
x <- c(r, s)

crosstab(x)

rs <- r/s
r[1:5] <- NA
s[20:25] <- NA
x <- c(r, s, rs)
crosstab(x, useNA=TRUE, long=TRUE)

```

crs

Get or set a coordinate reference system

Description

Get or set the coordinate reference system (CRS), also referred to as a "projection", of a `SpatRaster` or `SpatVector` object.

Setting a new CRS does not change the data itself, it just changes the label. So you should only set the CRS of a dataset (if it does not come with one) to what it *is*, not to what you would *like it to be*. See [project](#) to *transform* an object from one CRS to another.

Usage

```

## S4 method for signature 'SpatRaster'
crs(x, proj=FALSE, describe=FALSE, parse=FALSE)

## S4 method for signature 'SpatVector'
crs(x, proj=FALSE, describe=FALSE, parse=FALSE)

## S4 replacement method for signature 'SpatRaster'
crs(x)<-value

## S4 replacement method for signature 'SpatVector'
crs(x)<-value

```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>proj</code>	logical. If TRUE the crs is returned in PROJ-string notation
<code>describe</code>	logical. If TRUE the name, EPSG code, and the name and extent of the area of use are returned if known

value	character string describing a coordinate reference system. This can be in a WKT format, as a <authority:number> code such as "EPSG:4326", or a PROJ-string format such as "+proj=utm +zone=12" (see Note)
parse	logical. If TRUE, wkt parts are parsed into a vector (each line becomes an element)

Value

character or modified SpatRaster/Vector

Note

Projections are handled by the PROJ/GDAL libraries. Recent changes in the PROJ library to improve transformations between datums have degraded the library's usability. The PROJ developers suggest to no longer use the proj-string notation to define a CRS, but use the WKT2 or <authority>:<code> notation instead. These alternative systems work for formally described CRSs that are in databases, but they do not cover the infinite number of CRSs that exist. It is not practical to define one's own custom CRS with WKT2. Moreover, unlike the proj-notation, these newer systems are hard to read and that leads to code that cannot be easily understood and, therefore, is more error-prone.

It is still possible to use the PROJ-string notation with one major caveat: the datum should be WGS84 (or the equivalent NAD83) – if you want to transform your data to a coordinate reference system with a different datum. Thus as long as you use WGS84, or an ellipsoid instead of a datum, you can safely use PROJ-strings to represent your CRS; including to define your own custom CRS.

Examples

```
r <- rast()
crs(r)
crs(r, describe=TRUE, proj=TRUE)

crs(r) <- "+proj=lcc +lat_1=48 +lat_2=33 +lon_0=-100 +ellps=WGS84"
crs(r)

# You can also use epsg codes
crs(r) <- "epsg:25831"
crs(r, describe=TRUE)$area
```

density

Density plot

Description

Create density plots of the cell values of a SpatRaster

Usage

```
## S4 method for signature 'SpatRaster'
density(x, maxcells=100000, plot=TRUE, main, ...)
```


Arguments

x	SpatRaster
maxcells	the maximum number of (randomly sampled) cells to be used for creating the plot
plot	if TRUE produce a plot, else return a density object
main	character. Caption of plot(s)
...	additional arguments passed to plot

Value

density plot (and a density object, returned invisibly if plot=TRUE)

Examples

```
logo <- rast(system.file("ex/logo.tif", package="terra"))
density(logo)
```

depth	<i>depth of SpatRaster layers</i>
-------	-----------------------------------

Description

Get or set the depth of the layers of a SpatRaster. Experimental.

Usage

```
## S4 method for signature 'SpatRaster'
depth(x)

## S4 replacement method for signature 'SpatRaster'
depth(x)<-value
```

Arguments

x	SpatRaster
value	numeric vector

Value

numeric

See Also

[time](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))

depth(s) <- 1:3
depth(s)
```

describe

*describe***Description**

Describe the properties of spatial data in a file as generated with the "GDALinfo" tool.

Usage

```
## S4 method for signature 'character'
describe(x, sds=FALSE, meta=FALSE, parse=FALSE, options="", print=FALSE, open_opt="")
```

Arguments

x	character. The name of a file with spatial data. Or a fully specified subdataset within a file such as "NETCDF:\AVHRR.nc\NDVI"
sds	logical. If TRUE the description or metadata of the subdatasets is returned (if available)
meta	logical. Get the file level metadata instead
parse	logical. If TRUE, metadata for subdatasets is parsed into components (if meta=TRUE)
options	character. A vector of valid options (if meta=FALSE) including "json", "mm", "stats", "hist", "nogcp", "nomd", "norat", "noct", "nofl", "checksum", "proj4", "listmdd", "mdd <value>" where <value> specifies a domain or 'all', "wkt_format <value>" where value is one of 'WKT1', 'WKT2', 'WKT2_2015', or 'WKT2_2018', "sd <subdataset>" where <subdataset> is the name or identifier of a sub-dataset. See https://gdal.org/programs/gdalinfo.html . Ignored if sds=TRUE
print	logical. If TRUE, print the results
open_opt	character. Driver specific open options

Value

character (invisibly, if print=FALSE)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
describe(f)
describe(f, meta=TRUE)
#g <- desc(f, options=c("json", "nomd", "proj4"))
#cat(g, "\n")
```

diff *Lagged differences*

Description

Compute the difference between consecutive layers in a `SpatRaster`.

Usage

```
## S4 method for signature 'SpatRaster'
diff(x, lag=1, filename="", ...)
```

Arguments

x	<code>SpatRaster</code>
lag	postive integer indicating which lag to use
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
d <- diff(s)
```

dimensions *Dimensions of a SpatRaster or SpatVector and related objects*

Description

Get the number of rows (`nrow`), columns (`ncol`), cells (`ncell`), layers (`nlyr`), sources (`nsrc`), the size `size` (`nlyr(x)*ncell(x)`), or spatial resolution of a `SpatRaster`.

`length` returns the number of sub-datasets in a `SpatRasterDataset` or `SpatVectorCollection`.

For a `SpatVector` `length(x)` is the same as `nrow(x)`.

You can also set the number of rows or columns or layers. When setting dimensions, all cell values are dropped.

Usage

```
## S4 method for signature 'SpatRaster'  
ncol(x)  
  
## S4 method for signature 'SpatRaster'  
nrow(x)  
  
## S4 method for signature 'SpatRaster'  
nlyr(x)  
  
## S4 method for signature 'SpatRaster'  
ncell(x)  
  
## S4 method for signature 'SpatRaster'  
nsrc(x)  
  
## S4 replacement method for signature 'SpatRaster,numeric'  
ncol(x)<-value  
  
## S4 replacement method for signature 'SpatRaster,numeric'  
nrow(x)<-value  
  
## S4 replacement method for signature 'SpatRaster,numeric'  
nlyr(x)<-value  
  
## S4 method for signature 'SpatRaster'  
res(x)  
  
## S4 replacement method for signature 'SpatRaster,numeric'  
res(x)<-value  
  
## S4 method for signature 'SpatRaster'  
xres(x)  
  
## S4 method for signature 'SpatRaster'  
yres(x)  
  
## S4 method for signature 'SpatVector'  
ncol(x)  
  
## S4 method for signature 'SpatVector'  
nrow(x)  
  
## S4 method for signature 'SpatVector'  
length(x)
```

Arguments

x SpatRaster or SpatVector or related objects
value For ncol and nrow: positive integer. For res: one or two positive numbers

Value

integer

See Also

[ext](#)

Examples

```
r <- rast()
ncol(r)
nrow(r)
nlyr(r)
dim(r)
nsrc(r)
ncell(r)

rr <- c(r,r)
nlyr(rr)
nsrc(rr)
ncell(rr)

nrow(r) <- 18
ncol(r) <- 36
# equivalent to
dim(r) <- c(18, 36)

dim(r)
dim(r) <- c(10, 10, 5)
dim(r)

xres(r)
yres(r)
res(r)

res(r) <- 1/120
# different xres and yres
res(r) <- c(1/120, 1/60)
```

Description

SpatRaster: Create a `SpatRaster` with a higher resolution (smaller cells). The values in the new `SpatRaster` are the same as in the larger original cells.

SpatVector: Separate multi-objects (points, lines, polygons) into single objects.

Usage

```
## S4 method for signature 'SpatRaster'  
disagg(x, fact, method="near", filename="", ...)
```

```
## S4 method for signature 'SpatVector'  
disagg(x)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>fact</code>	positive integer. Aggregation factor expressed as number of cells in each direction (horizontally and vertically). Or two integers (horizontal and vertical aggregation factor) or three integers (when also aggregating over layers)
<code>method</code>	character. Either "near" for nearest or "bilinear" for bilinear interpolation
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[aggregate](#), [resample](#)

Examples

```
r <- rast(ncols=10, nrows=10)  
rd <- disagg(r, fact=c(10, 2))  
ncol(rd)  
nrow(rd)  
values(r) <- 1:ncell(r)  
rd <- disagg(r, fact=c(4, 2))
```

distance	<i>Geographic distance</i>
----------	----------------------------

Description

If x is a SpatRaster:

If y is missing this method computes the distance, for all cells that are NA in SpatRaster x to the nearest cell that is not NA. If argument `grid=TRUE`, the distance is computed using a path that goes through the centers of the 8 neighboring cells.

If y is a SpatVector, the distance to that SpatVector is computed for all cells. For lines and polygons this is done after rasterization; and only the overlapping areas of the vector and raster are considered (for now).

If x is a SpatVector:

If y is missing, a distance matrix between all object in x is computed. An distance matrix object of class "dist" is returned.

If y is a SpatVector the geographic distance between all objects is computed (and a matrix is returned). If both sets have the same number of points, and `pairwise=TRUE`, the distance between each pair of objects is computed, and a vector is returned.

Usage

```
## S4 method for signature 'SpatRaster,missing'
distance(x, y, grid=FALSE, filename="", ...)

## S4 method for signature 'SpatRaster,SpatVector'
distance(x, y, filename="", ...)

## S4 method for signature 'SpatVector,ANY'
distance(x, y, sequential=FALSE, pairs=FALSE, symmetrical=TRUE)

## S4 method for signature 'SpatVector,SpatVector'
distance(x, y, pairwise=FALSE)

## S4 method for signature 'matrix,matrix'
distance(x, y, lonlat, pairwise=FALSE)

## S4 method for signature 'matrix,ANY'
distance(x, y, lonlat, sequential=FALSE)
```

Arguments

x	SpatRaster, SpatVector, or two-column matrix (x,y) or (lon,lat)
y	missing or SpatVector, or two-column matrix
grid	logical. If TRUE, distance is computed using a path that goes through the centers of the 8 neighboring cells

filename	character. Output filename
...	additional arguments for writing files as in writeRaster
sequential	logical. If TRUE, the distance between sequential geometries is returned
pairwise	logical. If TRUE and if x and y have the same size (number of rows), the pairwise distances are returned instead of the distances between all elements
lonlat	logical. If TRUE the coordinates are interpreted as angular (longitude/latitude). If FALSE they are interpreted as planar
pairs	logical. If TRUE a "from", "to", "distance" matrix is returned
symmetrical	logical. If TRUE and pairs=TRUE, the distance between a pair is only included once. The distance between geometry 1 and 3 is included, but the (same) distance between 3 and 1 is not

Value

SpatRaster or numeric or matrix or distance matrix (object of class "dist")

Note

The distance unit is in meters.

A distance matrix can be coerced into a matrix with `as.matrix`

Examples

```
#lonlat
r <- rast(ncols=36, nrows=18, crs="+proj=longlat +datum=WGS84")
r[500] <- 1
d <- distance(r)
plot(d / 100000)

#planar
r <- rast(ncols=36, nrows=18, crs="+proj=utm +zone=1 +datum=WGS84")
r[500] <- 1
d <- distance(r)

p1 <- vect(rbind(c(0,0), c(90,30), c(-90,-30)), crs="+proj=longlat +datum=WGS84")
dp <- distance(r, p1)

d <- distance(p1)
d
as.matrix(d)

p2 <- vect(rbind(c(30,-30), c(25,40), c(-9,-3)), crs="+proj=longlat +datum=WGS84")
dd <- distance(p1, p2)
dd
pd <- distance(p1, p2, pairwise=TRUE)
pd
pd == diag(dd)
```



```

# polygons, lines
crs <- "+proj=utm +zone=1"
p1 <- vect("POLYGON ((0 0, 8 0, 8 9, 0 9, 0 0))", crs=crs)
p2 <- vect("POLYGON ((5 6, 15 6, 15 15, 5 15, 5 6))", crs=crs)
p3 <- vect("POLYGON ((2 12, 3 12, 3 13, 2 13, 2 12))", crs=crs)
p <- rbind(p1, p2, p3)
L1 <- vect("LINESTRING(1 11, 4 6, 10 6)", crs=crs)
L2 <- vect("LINESTRING(8 14, 12 10)", crs=crs)
L3 <- vect("LINESTRING(1 8, 12 14)", crs=crs)
lns <- rbind(L1, L2, L3)
pts <- vect(cbind(c(7,10,10), c(3,5,6)), crs=crs)

distance(p1,p3)
distance(p)
distance(p,pts)
distance(p,lns)
distance(pts,lns)

```

dots

Make a dot-density map

Description

Create the dots for a dot-density map and add these to the current map. Dot-density maps are made to display count data. For example of population counts, where each dot represents *n* persons. The dots are returned as a `SpatVector`. If there is an active graphics device, the dots are added to it with [points](#).

Usage

```

## S4 method for signature 'SpatVector'
dots(x, field, size, ...)

```

Arguments

<code>x</code>	<code>SpatVector</code>
<code>field</code>	character of numeric indicating field name. Or numeric vector of the same length as <code>x</code>
<code>size</code>	positive number indicating the number of cases associated with each dot
<code>...</code>	graphical arguments passed to <code>points</code>

Value

`SpatVector` (invisibly)

See Also

[plot](#), [cartogram](#), [points](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v$population <- 1000*(1:12)^2
plot(v)
#d <- dots(v, "population", 10000)
#d
```

draw

Draw a polygon, line, extent, or points

Description

Draw on a plot (map) to get a `SpatVector` or `SpatExtent` object for later use. After calling the function, start clicking on the map. When you are done, press ESC. You can also preset the maximum number of clicks.

Usage

```
## S4 method for signature 'character'
draw(x="extent", col="red", lwd=2, id=FALSE, n=1000, ...)
```

Arguments

<code>x</code>	character. The type of object to draw. One of "extent", "polygon", "line", or "points"
<code>col</code>	the color to be used
<code>lwd</code>	the width of the lines to be drawn
<code>id</code>	logical. If TRUE, a numeric ID is shown on the map
<code>n</code>	the maximum number of clicks (does not apply when <code>x=="extent"</code> in which case <code>n</code> is always 2)
<code>...</code>	additional graphics arguments for drawing

Value

`SpatVector` or `SpatExtent`

See Also

[click](#)

erase	<i>Erase parts of a SpatVector object</i>
-------	---

Description

Erase parts of a SpatVector with another SpatVector (or SpatExtent). The inverse of this can be done with [intersect](#) and [crop](#).

Usage

```
## S4 method for signature 'SpatVector,SpatVector'  
erase(x, y)  
  
## S4 method for signature 'SpatVector,SpatExtent'  
erase(x, y)
```

Arguments

x	SpatVector
y	SpatVector or SpatExtent

Value

SpatVector or SpatExtent

See Also

The equivalent for SpatRaster is [mask](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")  
v <- vect(f)  
e <- ext(5.6, 6, 49.55, 49.7)  
x <- erase(v, e)  
  
p <- vect("POLYGON ((5.8 49.8, 6 49.9, 6.15 49.8, 6 49.6, 5.8 49.8))")  
y <- erase(v, p)
```

expand

*Extend***Description**

Enlarge the spatial extent of a `SpatRaster`. See [crop](#) if you (also) want to remove rows or columns. You can also enlarge a `SpatExtent` with this method, or with algebraic notation (see examples)

Usage

```
## S4 method for signature 'SpatRaster'
extend(x, y, filename="", overwrite=FALSE, ...)

## S4 method for signature 'SpatExtent'
extend(x, y)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatExtent</code>
<code>y</code>	If <code>x</code> is a <code>SpatRaster</code> , <code>y</code> should be a <code>SpatExtent</code> , or an object from which it can be extracted (such as <code>SpatRaster</code> and <code>SpatVector</code> objects). Alternatively, you can provide two positive integers indicating the number of rows and columns that need to be added at each side (or a single positive integer when the number of rows and columns is equal) If <code>x</code> is a <code>SpatExtent</code> , <code>y</code> should be a numeric vector of 1, 2, or 4 elements
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If TRUE, <code>filename</code> is overwritten
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster` or `SpatExtent`

See Also

[crop](#), [merge](#), [ext](#)

Examples

```
r <- rast(xmin=-150, xmax=-120, ymin=30, ymax=60, ncols=36, nrows=18)
values(r) <- 1:ncell(r)
e <- ext(-180, -100, 40, 70)
re <- extend(r, e)

# expand with a number of rows and columns (at each side)
re2 <- extend(r, c(2,10))
```

```
# SpatExtent
e <- ext(r)
e
extend(e, 10)
extend(e, c(10, -10, 0, 20))
```

expanse	<i>Get the expanse (area) of individual polygons or for all (summed) raster cells</i>
---------	---

Description

Compute the area covered by polygons or for all raster cells that are not NA.

This method computes areas for longitude/latitude rasters, as the size of the cells is constant in degrees, but not in meters. But it can also be important if the coordinate reference system is planar, but not equal-area.

For vector data, the best way to compute area is to use the longitude/latitude CRS. This is contrary to (erroneous) popular belief that suggest that you should use a planar coordinate reference system. This is done automatically, if `transform=TRUE`.

Usage

```
## S4 method for signature 'SpatRaster'
expanse(x, unit="m", transform=TRUE)
```

```
## S4 method for signature 'SpatVector'
expanse(x, unit="m", transform=TRUE)
```

Arguments

<code>x</code>	SpatRaster or SpatVector
<code>unit</code>	character. One of "m", "km", or "ha"
<code>transform</code>	logical. If TRUE, planar CRS are transformed to lon/lat for accuracy

Value

numeric. The sum of the size of the cells that are not NA

See Also

[cellSize](#) for a the size of individual cells of a raster, that can be summed with [global](#) or with [zonal](#) to get the area for different categories.

Examples

```
### SpatRaster
r <- rast(nrows=18, ncols=36)
v <- 1:ncell(r)
v[200:400] <- NA
values(r) <- v

# summed area in km2
expanse(r, unit="km")

r <- rast(ncols=90, nrows=45, ymin=-80, ymax=80)
m <- project(r, "+proj=merc")

expanse(m, unit="km")
expanse(m, unit="km", transform=FALSE)

### SpatVector
v <- vect(system.file("ex/lux.shp", package="terra"))

a <- expanse(v)
a
sum(a)
```

 ext

Create, get or set a SpatExtent

Description

Get a `SpatExtent` of a `SpatRaster`, or coordinates from such an object. Or create a `SpatExtent` from a vector (length=4; order= xmin, xmax, ymin, ymax)

Usage

```
## S4 method for signature 'SpatRaster'
ext(x)

## S4 method for signature 'numeric'
ext(x, ...)

## S4 replacement method for signature 'SpatRaster,SpatExtent'
ext(x)<-value

## S4 replacement method for signature 'SpatRaster,numeric'
ext(x)<-value

## S4 method for signature 'SpatExtent'
x$name
```

```
## S4 replacement method for signature 'SpatExtent'
x$name<-value
```

Arguments

x	SpatRaster
value	SpatExtent, or numeric vector of length four (xmin, xmax, ymin, ymax), or a single number with the \$ method
name	character, one of xmin, xmax, ymin, or ymax
...	if x is a single numeric value, additional numeric values for xmax, ymin, and ymax

Value

SpatExtent

Examples

```
r <- rast()
e <- ext(r)
as.vector(e)
as.character(e)

ext(r) <- c(0, 2.5, 0, 1.5)
r
er <- ext(r)

round(er)
# go "in"
floor(er)
# go "out"
ceiling(er)

ext(r) <- e
```

extract

Extract values from a SpatRaster

Description

Extract values from a SpatRaster for a set of locations. The locations can be a SpatVector (points, lines, polygons), a matrix with (x, y) or (longitude, latitude – in that order!) coordinates, or a vector with cell numbers.

When argument y is a SpatVector, and list=FALSE, the first column has the ID (record number) of the SpatVector used.

Usage

```
## S4 method for signature 'SpatRaster,SpatVector'
extract(x, y, fun=NULL, method="simple", list=FALSE, factors=TRUE,
        cells=FALSE, xy=FALSE, weights=FALSE, exact=FALSE,
        touches=is.lines(y), layer=NULL, ...)
```

```
## S4 method for signature 'SpatRaster,SpatExtent'
extract(x, y, factors=TRUE, cells=FALSE, xy=FALSE)
```

```
## S4 method for signature 'SpatRaster,matrix'
extract(x, y, ...)
```

```
## S4 method for signature 'SpatRaster,numeric'
extract(x, y, ...)
```

Arguments

x	SpatRaster
y	SpatVector (for points, lines, polygons), or for points, 2-column matrix or data.frame (x, y) or (lon, lat), or a vector with cell numbers
fun	function to summarize the data by geometry. If weights=TRUE or exact=TRUE only codemean, sum, min and max are accepted)
...	additional arguments to fun if y is a SpatVector. For example na.rm=TRUE. Or arguments passed to the SpatRaster, SpatVector method if y is a matrix (such as the method and cells arguments)
method	character. method for extracting values with points ("simple" or "bilinear"). With "simple" values for the cell a point falls in are returned. With "bilinear" the returned values are interpolated from the values of the four nearest raster cells
list	logical. If FALSE the output is simplified to a matrix (if fun=NULL)
factors	logical. If TRUE the categories are returned as factors instead of their numerical representation. The value returned becomes a data.frame if it otherwise would have been a matrix, even if there are no factors
cells	logical. If TRUE the cell numbers are also returned, unless fun is not NULL. Also see cells
xy	logical. If TRUE the coordinates of the cells are also returned, unless fun is not NULL. Also see xyFromCell
weights	logical. If TRUE and y has polygons, the approximate fraction of each cell that is covered is returned as well, for example to compute a weighted mean
exact	logical. If TRUE and y has polygons, the exact fraction of each cell that is covered is returned as well, for example to compute a weighted mean
touches	logical. If TRUE, values for all cells touched by lines or polygons are extracted, not just those on the line render path, or whose center point is within the polygon. Not relevant for points; and always considered TRUE when weights=TRUE or exact=TRUE

`layer` character or numeric to select the layer to extract from for each geometry. If `layer` is a character it can be a name in `y` or a vector of layer names. If it is numeric, it must be integer values between 1 and `nlyr(x)`

Value

matrix, list, or data.frame

See Also

[values](#)

Examples

```
r <- rast(ncols=5, nrows=5, xmin=0, xmax=5, ymin=0, ymax=5)
values(r) <- 1:25
xy <- rbind(c(0.5,0.5), c(2.5,2.5))
p <- vect(xy, crs="+proj=longlat +datum=WGS84")

extract(r, xy)
extract(r, p)

r[1,]
r[5]
r[,5]

r[c(0:2, 99:101)]

f <- system.file("ex/meuse.tif", package="terra")
r <- rast(f)

xy <- cbind(179000, 330000)
xy <- rbind(xy-100, xy, xy+1000)
extract(r, xy)

p <- vect(xy)
g <- geom(p)
g

extract(r, p)

x <- r + 10
extract(x, p)

i <- cellFromXY(r, xy)
x[i]
r[i]

y <- c(x,x*2,x*3)
y[i]

## extract with a polygon
```

```

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v <- v[1:2,]
z <- rast(v, resolution=.1, names="test")
values(z) <- 1:ncell(z)

rf <- system.file("ex/elev.tif", package="terra")
x <- rast(rf)
#extract(x, v, mean, na.rm=TRUE)

#e <- extract(z, v)
#e
#tapply(e[,2], e[,1], mean, na.rm=TRUE)

#ee <- extract(z, v, list=TRUE)
#rapply(ee, mean)

#x <- c(z, z*2, z/3)
#names(x) <- letters[1:3]

#e <- extract(x, v)
#de <- data.frame(e)
#aggregate(de[,2:4], de[,1],drop=FALSE], mean)

#ee <- extract(x, v, list=TRUE)
#matrix(rapply(ee, mean), ncol=nlyr(x), byrow=TRUE)

```

extremes

Get or compute the minimum and maximum cell values

Description

The minimum and maximum value of a `SpatRaster` are returned or computed (from a file on disk if necessary) and stored in the object.

Usage

```

## S4 method for signature 'SpatRaster'
minmax(x)
## S4 method for signature 'SpatRaster'
setMinMax(x, force=FALSE)

```

Arguments

x	<code>SpatRaster</code>
force	logical. If TRUE min and max values are recomputed even if already available

Value

setMinMax: nothing. Used for the side-effect of computing the minimum and maximum values of a SpatRaster

minmax: numeric matrix of minimum and maximum cell values by layer

Examples

```
r <- rast(system.file("ex/elev.tif", package="terra"))
minmax(r)
```

factors

Categorical rasters

Description

A SpatRaster layer can be a categorical variable (factor). Like [factors](#), categories are stored as indices (integers) that have an associated label. For a SpatRaster, the index starts at 0, and cannot exceed 255.

The categories can be inspected with `levels` and `cats`. With `levels<-` you can set the categories of the first layer by providing a vector of labels (the first value will be for cells with value 0, the second for 1, etc). You can also provide a data.frame that must have two or more columns, the first one identifying the cell values and the other column(s) providing the category labels. To set categories for multiple layers you can provide `levels<-` with a list with one element for each layer.

With `setCats` you can set it for any layer and you can also set the "active" category if there are multiple categories.

Usage

```
## S4 method for signature 'SpatRaster'
is.factor(x)

## S4 method for signature 'SpatRaster'
levels(x)

## S4 replacement method for signature 'SpatRaster'
levels(x)<-value

## S4 method for signature 'SpatRaster'
cats(x, layer)

## S4 method for signature 'SpatRaster'
setCats(x, layer=1, value, index)
```

Arguments

x	SpatRaster
layer	positive integer, the layer number or name
value	a data.frame (ID, category) or vector with category names
index	positive integer, indicating the column in data.frame value to be used as the category, skipping the first column with the ID.

Value

list (levels, cats) or data.frame (cats for a single layer); logical (is.factor, setCats)

See Also

[activeCat](#), [catalyze](#)

Examples

```
set.seed(0)
r <- rast(nrows=10, ncols=10)
values(r) <- sample(3, ncell(r), replace=TRUE)
is.factor(r)

cls <- c("forest", "water", "urban")
# make the raster start at zero
x <- r - 1
levels(x) <- cls
names(x) <- "land cover"
is.factor(x)
x

plot(x, col=c("green", "blue", "light gray"))
text(x, digits=3, cex=.75, halo=TRUE)

# raster starts at 3
x <- r + 2
is.factor(x)

# approach 1
levels(x) <- c("", "", "", "forest", "water", "urban")

# approach 2, also showing the use of two categories
d <- data.frame(id=3:5, cover=cls, letters=letters[1:3], value=10:12)
levels(x) <- d
x

## switch categories
cats(x, 1)
# get current index
activeCat(x)
# set index
```

```

activeCat(x) <- 3
plot(x, col=c("green", "blue", "light gray"))
text(x, digits=3, cex=.75, halo=TRUE)

r <- as.numeric(x)
r

#activeCat(x) <- 2
#p <- as.polygons(x)
#plot(p, "letters", col=c("green", "blue", "light gray"))

```

fillHoles

Remove holes from polygons

Description

Remove the holes in `SpatVector` polygons. If `inverse=TRUE` the holes are returned (as polygons).

Usage

```

## S4 method for signature 'SpatVector'
fillHoles(x, inverse=FALSE)

```

Arguments

<code>x</code>	<code>SpatVector</code>
<code>inverse</code>	logical. If <code>TRUE</code> the holes are returned as polygons

Value

`SpatVector`

Examples

```

x <- rbind(c(-10,0), c(140,60), c(160,0), c(140,-55))
hole <- rbind(c(80,0), c(105,13), c(120,2), c(105,-13))

z <- rbind(cbind(object=1, part=1, x, hole=0),
          cbind(object=1, part=1, hole, hole=1))
colnames(z)[3:4] <- c('x', 'y')
p <- vect(z, "polygons", atts=data.frame(id=1))
p

f <- fillHoles(p)
g <- fillHoles(p, inverse=TRUE)

plot(p, lwd=16, border="gray", col="light yellow")
polys(f, border="blue", lwd=3, density=4, col="orange")
polys(g, col="white", lwd=3)

```

flip *Flip or reverse a raster*

Description

Flip the values of a `SpatRaster` by inverting the order of the rows (`vertical=TRUE`) or the columns (`vertical=FALSE`).

`rev` is the same as a horizontal *and* a vertical flip.

Usage

```
## S4 method for signature 'SpatRaster'
flip(x, direction="vertical", filename="", ...)

## S4 method for signature 'SpatVector'
flip(x, direction="vertical")

## S4 method for signature 'SpatRaster'
rev(x)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>direction</code>	character. Should (partially) match "vertical" to flip by rows, or "horizontal" to flip by columns
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

See Also

[trans](#), [rotate](#)

Examples

```
r <- rast(nrow=18, ncol=36)
m <- matrix(1:ncell(r), nrow=18)
values(r) <- as.vector(t(m))
rx <- flip(r, direction="h")

values(r) <- as.vector(m)
ry <- flip(r, direction="v")

v <- rev(r)
```

focal	<i>Focal values</i>
-------	---------------------

Description

Calculate focal ("moving window") values for the neighborhood of focal cells using a matrix of weights, perhaps in combination with a function.

Usage

```
## S4 method for signature 'SpatRaster'
focal(x, w=3, fun="sum", na.rm=TRUE, na.only=FALSE,
      fillvalue=NA, expand=FALSE, filename="", ...)
```

Arguments

x	SpatRaster
w	window. The window can be defined as one (for a square) or two numbers (row, col); or with an odd-sized weights matrix. See Details.
fun	function that takes multiple numbers, and returns a single number. For example mean, modal, min or max. It should also accept a na.rm argument, either as actual argument or through use of ...
na.rm	logical. Should missing values be removed?
na.only	logical. Should only missing values in x be changed?
fillvalue	numeric. The value of the cells in the virtual rows and columns outside of the raster
expand	logical. If TRUE The value of the cells in the virtual rows and columns outside of the raster are set to be the same as the value on the border
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Details

focal

The window used must have odd dimensions. If you need even sides, you can use a matrix and add a column or row with weights of zero.

Window values are typically 0 or 1, or a value between 0 and 1 if you are using a rectangular area and/or the "sum" function. They can also be NA; these are ignored in the computation. That can be useful to compute the mean, min, or max value for a non-rectangular area.

Example weight matrices

Laplacian filter: `filter=matrix(c(0,1,0,1,-4,1,0,1,0),nrow=3)`

Sobel filters (for edge detection): `fx=matrix(c(-1,-2,-1,0,0,0,1,2,1),nrow=3)` `fy=matrix(c(1,0,-1,2,0,-2,1,0,-`

Value

SpatRaster

See Also[focalMat](#), [focalValues](#)**Examples**

```

r <- rast(ncols=10, nrows=10, ext(0, 10, 0, 10))
values(r) <- 1:ncell(r)

#f <- focal(r, w=3, fun=function(x, ...) quantile(x, .25, ...), na.rm=TRUE)

f <- focal(r, w=3, fun="mean")

# the following two statements are equivalent:
a <- focal(r, w=matrix(1/9, nc=3, nr=3))
b <- focal(r, w=3, fun=mean, na.rm=FALSE)

# but this is different
d <- focal(r, w=3, fun=mean, na.rm=TRUE)

```

focalMat

*Focal weights matrix***Description**

Make a focal ("moving window") weight matrix for use in the [focal](#) function. The sum of the values adds up to one.

Usage

```
focalMat(x, d, type=c('circle', 'Gauss', 'rectangle'))
```

Arguments

x	SpatRaster
d	numeric. If type=circle, the radius of the circle (in units of the crs). If type=rectangle the dimension of the rectangle (one or two numbers). If type=Gauss the size of sigma, and optionally another number to determine the size of the matrix returned (default is 3*sigma)
type	character indicating the type of filter to be returned

Valuematrix that can be used with [focal](#)

Examples

```
r <- rast(ncols=180, nrows=180, xmin=0)
focalMat(r, 2, "circle")

focalMat(r, c(2,3), "rect")

# Gaussian filter for square cells
gf <- focalMat(r, 1, "Gauss")
```

focalValues	<i>Get focal values</i>
-------------	-------------------------

Description

Get a matrix in which each row had the focal values of a cell. These are the values of a cell and a rectangular window around it.

Usage

```
## S4 method for signature 'SpatRaster'
focalValues(x, w=3, row=1, nrows=nrow(x), fill=NA)
```

Arguments

x	SpatRaster or SpatVector
w	window. The window can be defined as one (for a square) or two odd numbers (row, col); or with an odd sized matrix
row	positive integer. Row number to start from, should be between 1 and nrow(x)
nrows	positive integer. How many rows?
fill	numeric used as values for imaginary cells outside the raster

Value

matrix

Examples

```
r <- rast(ncol=4, nrow=4, crs="+proj=utm +zone=1 +datum=WGS84")
values(r) <- 1:ncell(r)
focalValues(r)
```

freq	<i>Frequency table</i>
------	------------------------

Description

Frequency table of the values of a `SpatRaster`. NAs are not counted unless `value=NA`.

Usage

```
## S4 method for signature 'SpatRaster'
freq(x, digits=0, value=NULL, bylayer=TRUE, usenames=FALSE)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>digits</code>	integer. Used for rounding the values before tabulation. Ignored if NA
<code>value</code>	numeric. An optional single value to only count the number of cells with that value. This value can be NA
<code>bylayer</code>	logical. If TRUE tabulation is done by layer
<code>usenames</code>	logical. If TRUE layers are identified by their names instead of their numbers. Only relevant if <code>bylayer</code> is TRUE

Value

matrix or `data.frame` with 3 columns (layer, value, count) or, if `bylayer=FALSE` two columns (value, count). If any of the layers of `x` is categorical, there is an additional column (label). A `data.frame` is returned if `usenames=TRUE` or if any of the layers of `x` is categorical.

Examples

```
r <- rast(nrows=10, ncols=10)
set.seed(2)
values(r) <- sample(5, ncell(r), replace=TRUE)

freq(r)

x <- c(r, r/3)
freq(x, bylayer=FALSE)
freq(x)

freq(x, digits=1)
freq(x, digits=-1)

freq(x, value=5)
```

gdal	<i>GDAL version and supported file formats</i>
------	--

Description

Set the GDAL warning level or get a `data.frame` with the available GDAL drivers (file formats), or get the GDAL version (if `warn=NA` and `drivers=FALSE`, the default).

GDAL is the software library that terra builds on to read and write spatial data and for some raster data processing.

Usage

```
gdal(warn=NA, drivers=FALSE)
```

Arguments

<code>warn</code>	ignored if NA. Otherwise, the value should be an integer between 1 and 4 representing the level of GDAL warnings and errors that are passed to R. 1 = warnings and errors; 2 = errors only (recoverable errors as a warning); 3 = irrecoverable errors only; 4 = ignore all errors and warnings. The default setting is 3
<code>drivers</code>	logical. If TRUE a <code>data.frame</code> with the raster and vector data formats that are available.

Value

character

See Also

[describe](#) for file-level metadata "GDALinfo"

Examples

```
gdal()
gdal(2)
head(gdal(drivers=TRUE))
```

geom

*Get the geometry (coordinates) of a SpatVector***Description**

Get the geometry of a SpatVector. If wkt=FALSE, this is a five-column matrix or data.frame: the vector object ID, the IDs for the parts of each object (e.g. five polygons that together are one spatial object), the x (longitude) and y (latitude) coordinates, and a flag indicating whether the part is a "hole" (only relevant for polygons).

If wkt=TRUE, the "well-known text" representation is returned as a character vector.

Usage

```
## S4 method for signature 'SpatVector'
geom(x, wkt=FALSE, hex=FALSE, df=FALSE)
```

Arguments

x	SpatVector
wkt	logical. If TRUE the WKT geometry is returned (unless hex is also TRUE)
hex	logical. If TRUE the hexadecimal geometry is returned
df	logical. If TRUE a data.frame is returned in stead of a matrix (only for wkt=FALSE and hex=FALSE)

Value

matrix

See Also

See [xyFromCell](#) to get the coordinates of the cells of a SpatRaster

Examples

```
x1 <- rbind(c(-175,-20), c(-140,55), c(10, 0), c(-140,-60))
x2 <- rbind(c(-125,0), c(0,60), c(40,5), c(15,-45))
x3 <- rbind(c(-10,0), c(140,60), c(160,0), c(140,-55))
x4 <- rbind(c(80,0), c(105,13), c(120,2), c(105,-13))
z <- rbind(cbind(object=1, part=1, x1), cbind(object=2, part=1, x2),
          cbind(object=3, part=1, x3), cbind(object=3, part=2, x4))
colnames(z)[3:4] <- c('x', 'y')
z <- cbind(z, hole=0)
z[(z[, "object"]==3 & z[, "part"]==2), "hole"] <- 1

p <- vect(z, "polygons")
geom(p)
```

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
g <- geom(v)
head(g)

w <- geom(v, wkt=TRUE)
substr(w, 1, 60)
```

geomtype

Geometry type of a SpatVector

Description

Get the geometry type (points, lines, or polygons) of a SpatVector or the data types of the fields (attributes, variables) of a SpatVector.

Usage

```
## S4 method for signature 'SpatVector'
geomtype(x)

## S4 method for signature 'SpatVector'
datatype(x)

## S4 method for signature 'SpatVector'
is.points(x)

## S4 method for signature 'SpatVector'
is.lines(x)

## S4 method for signature 'SpatVector'
is.polygons(x)
```

Arguments

x SpatVector

Value

character

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

geomtype(v)
is.polygons(v)
is.lines(v)
```

```
is.points(v)
names(v)
datatype(v)
```

global	<i>global statistics</i>
--------	--------------------------

Description

Compute global statistics, that is summarized values of an entire SpatRaster.

If x is very large global will fail, except when fun is one of "mean", "min", "max", or "sum".

You can compute a weighted mean or sum by providing a SpatRaster with weights.

Usage

```
## S4 method for signature 'SpatRaster'
global(x, fun="mean", weights=NULL, ...)
```

Arguments

x	SpatRaster
fun	function to be applied to summarize the values by zone. Either as one of these character values: "max", "min", "mean", "sum", "range", "rms" (root mean square), "sd", "sdpop" (population sd, using n rather than n-1); or, for relatively small SpatRasters, a proper function
...	additional arguments passed on to fun
weights	NULL or SpatRaster

Value

A data.frame with a row for each layer

See Also

[zonal](#) for "zonal" statistics, and [app](#) or [Summary-methods](#) for "local" statistics, and [extract](#) for summarizing values for polygons. Also see [focal](#) for "focal" or "moving window" operations.

Examples

```
r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
global(r, "sum")
global(r, "mean", na.rm=TRUE)
```

head and tail	<i>Show the head or tail of a Spat* object</i>
---------------	--

Description

Show the head (first values) or tail (last values) of a SpatRaster or of the attributes of a SpatVector.

Usage

```
head(x, ...)  
tail(x, ...)
```

Arguments

x	SpatRaster or SpatVector
...	additional arguments passed on to other methods

Value

matrix (SpatRaster) or data.frame (SpatVector)

See Also

[show](#), [geom](#)

Examples

```
r <- rast(nrows=25, ncols=25)  
values(r) <- 1:ncell(r)  
head(r)  
tail(r)
```

hist	<i>Histogram</i>
------	------------------

Description

Create a histogram of the values of a SpatRaster. For large datasets a sample of maxcell is used.

Usage

```
## S4 method for signature 'SpatRaster'  
hist(x, layer, maxcell=1000000, plot=TRUE, main, ...)
```

Arguments

x	SpatRaster
layer	integer (or character) to indicate layer number (or name). Can be used to subset the layers to plot in a multilayer SpatRaster
maxcell	integer. To regularly sample very large objects
plot	logical. Plot the histogram or only return the histogram values
main	character. Main title(s) for the plot. Default is the value of <code>names</code>
...	additional arguments. See hist

Value

This function is principally used for plotting a histogram, but it also returns an object of class "histogram" (invisibly if `plot=TRUE`).

See Also

[pairs](#), [boxplot](#)

Examples

```
r1 <- r2 <- rast(nrows=50, ncols=50)
values(r1) <- runif(ncell(r1))
values(r2) <- runif(ncell(r1))
rs <- r1 + r2
rp <- r1 * r2

opar <- par(no.readonly =TRUE)
par(mfrow=c(2,2))
plot(rs, main='sum')
plot(rp, main='product')
hist(rs)
a <- hist(rp)
a
x <- c(rs, rp, sqrt(rs))
hist(x)
par(opar)
```

ifel

ifelse for SpatRasters

Description

Implementation of [ifelse](#) for SpatRasters. This method allows for a concise approach to what can otherwise be achieved with a combination of [classify](#), [mask](#), and [cover](#).

`ifel` is an R equivalent to the `Con` method in ArcGIS (`arcpy`).

Usage

```
## S4 method for signature 'SpatRaster'  
ifel(test, yes, no, filename="", ...)
```

Arguments

test	SpatRaster
yes	SpatRaster or numeric
no	SpatRaster or numeric
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
r <- rast(nrows=5, ncols=5, xmin=0, xmax=1, ymin=0, ymax=1)  
values(r) <- c(-10:0, NA, NA, NA, 0:10)  
  
x <- ifel(r > 1, 1, r)  
# same as  
a <- classify(r, cbind(1, Inf, 1))  
# or  
b <- app(r, fun=function(i) {i[i > 1] <- 1; i})  
# or  
d <- clamp(r, -Inf, 1)  
# or (not recommended for large datasets)  
e <- r  
e[e>1] <- 1  
  
## other examples  
f <- ifel(is.na(r), 100, r)  
  
z <- ifel(r > -2 & r < 2, 100, 0)  
  
# nested expressions  
y <- ifel(r > 1, 1, ifel(r < -1, -1, r))  
  
k <- ifel(r > 0, r+10, ifel(r < 0, r-10, 3))
```

image	<i>SpatRaster image method</i>
-------	--------------------------------

Description

Plot (make a map of) the values of a `SpatRaster` via `image`. See `plot` if you need more fancy options such as a legend.

Usage

```
## S4 method for signature 'SpatRaster'
image(x, y=1, maxcell=50000, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>y</code>	positive integer indicating the layer to be plotted, or a character indicating the name of the layer
<code>maxcell</code>	positive integer. Maximum number of cells to use for the plot
<code>...</code>	additional arguments as for <code>graphics::image</code>

See Also

[plot](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
image(r)
image(r, col=rainbow(24))
```

initialize	<i>Initialize a SpatRaster with values</i>
------------	--

Description

Create a `SpatRaster` with values reflecting a cell property: `'x'`, `'y'`, `'col'`, `'row'`, `'cell'` or `'chess'`. Alternatively, a function can be used. In that case, cell values are initialized without reference to pre-existing values. E.g., initialize with a random number (fun=`runif`). While there are more direct ways of achieving this for small objects (see examples) for which a vector with all values can be created in memory, the `init` function will also work for `SpatRaster` objects with many cells.

Usage

```
## S4 method for signature 'SpatRaster'
init(x, fun, filename="", ...)
```

Arguments

x	SpatRaster
fun	function to be applied. This must be either a single number, multiple numbers, a function, or one of a set of known character values. A function must take the number of cells as a single argument to return a vector of values with a length equal to the number of cells, such as <code>fun=runif</code> . Allowed character values are 'x', 'y', 'row', 'col', 'cell', and 'chess' to get the x or y coordinate, row, col or cell number or a chessboard pattern (alternating 0 and 1 values)
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
r <- rast(ncols=10, nrows=5, xmin=0, xmax=10, ymin=0, ymax=5)
x <- init(r, fun="cell")
y <- init(r, fun=runif)

# initialize with a single value
z <- init(r, fun=8)
```

inset	<i>Make an inset map</i>
-------	--------------------------

Description

Make an inset map or scale the extent of a SpatVector

Usage

```
## S4 method for signature 'SpatVector'
inset(x, e, loc="", scale=0.2, background="white", border="black", box=NULL, pbx, ...)

## S4 method for signature 'SpatRaster'
inset(x, e, loc="", scale=0.2, background="white", border="black", box=NULL, pbx, ...)

## S4 method for signature 'SpatVector'
inext(x, e, y=NULL, gap=0)
```

Arguments

x	SpatVector, SpatRaster
e	SpatExtent to set the size and location of the inset. Or missing
loc	character. One of "bottomright", "bottom", "bottomleft", "left", "topleft", "top", "topright", "right", "center"
scale	numeric. The relative size of the inset, used when x is missing
background	color for the background of the inset. Use NA for no background color
border	color for the border around the inset. Use NA for no border
box	SpatExtent or missing, to draw a box on the inset
pbx	list with graphical arguments for the box
...	additional arguments passed to plot for the drawing of x
y	SpatVector. If not NULL, y is scaled based with the parameters for x. This is useful, for example, when x represent boundaries, and y points within these boundaries
gap	numeric to add space between the SpatVector and the SpatExtent

Value

scaled and shifted SpatVector or SpatRaster (invisibly)

See Also

[sbar](#), [rescale](#), [shift](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
x <- v[v$NAME_2 == "Diekirch", ]

plot(x, density=10, col="blue")
inset(v)

cols <- rep("light grey", 12)
cols[2] <- "red"
e <- ext(c(6.2, 6.3, 49.9, 50))
b <- ext(x)+0.02
inset(v, e=e, col=cols, box=b)

# with a SpatRaster
ff <- system.file("ex/elev.tif", package="terra")
r <- rast(ff)
r <- crop(r, ext(x) + .01)
plot(r, type="int", mar=c(2,2,2,2), plg=list(x="topright"))
lines(v, lwd=1.5)
lines(x, lwd=2.5)
```

```

inset(v, col=cols, loc="topleft", scale=0.15)

# a more complex one
plot(r, plg=list(title="meter\n", shrink=.2, cex=.8))
lines(v, lwd=4, col="white")
lines(v, lwd=1.5)
lines(x, lwd=2.5)
text(x, "NAME_2", cex=1.5, halo=TRUE)
sbar(6, c(6.04, 49.785), type="bar", below="km", label=c(0,3,6), cex=.8)
s <- inset(v, col=cols, box=b, scale=.2, loc="topright", background="light yellow",
pbx=list(lwd=2, lty=5, col="blue"))

# note the returned inset SpatVector
s

```

intersect

Intersection

Description

Intersect the geometries of two SpatVectors.

Intersecting points with points uses the extent of y to get the intersection. Intersecting of points and lines is not supported because of numerical inaccuracies with that. You can use [buffer](#), to create polygons from lines and use these with intersect.

See [crop](#) for intersection of a SpatRaster.

Usage

```

## S4 method for signature 'SpatVector,SpatVector'
intersect(x, y)

## S4 method for signature 'SpatVector,SpatExtent'
intersect(x, y)

## S4 method for signature 'SpatExtent,SpatVector'
intersect(x, y)

## S4 method for signature 'SpatExtent,SpatExtent'
intersect(x, y)

```

Arguments

x	SpatVector or SpatExtent
y	SpatVector or SpatExtent

Value

Same as x

See Also

[union](#), [crop](#), [relate](#)

Examples

```
e1 <- ext(-10, 10, -20, 20)
e2 <- ext(0, 20, -40, 5)
intersect(e1, e2)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
e <- ext(5.6, 6, 49.55, 49.7)
x <- intersect(v, e)

p <- vect(c("POLYGON ((5.8 49.8, 6 49.9, 6.15 49.8, 6 49.6, 5.8 49.8))",
"POLYGON ((6.3 49.9, 6.2 49.7, 6.3 49.6, 6.5 49.8, 6.3 49.9))"), crs=crs(v))
values(p) <- data.frame(pid=1:2, area=expansion(p))

y <- intersect(v, p)
```

is.lonlat

Check for longitude/latitude crs

Description

Test whether a `SpatRaster` or `SpatVector` has a longitude/latitude coordinate reference system (CRS), or perhaps has one. That is when the CRS is unknown ("") but the x coordinates are within -181 and 181 and the y coordinates are within -90.1 and 90.1. For a `SpatRaster` you can also test if it is longitude/latitude and "global" (covers all longitudes).

The form `isLonLat` is deprecated. Use `is.lonlat`

Usage

```
## S4 method for signature 'SpatRaster'
is.lonlat(x, perhaps=FALSE, warn=TRUE, global=FALSE)

## S4 method for signature 'SpatVector'
is.lonlat(x, perhaps=FALSE, warn=TRUE)

## S4 method for signature 'SpatRaster'
isLonLat(x)

## S4 method for signature 'SpatVector'
isLonLat(x)
```

Arguments

x	SpatRaster or SpatVector
perhaps	logical. If TRUE and the crs is unknown, the method returns TRUE if the coordinates are plausible for longitude/latitude
warn	logical. If TRUE, a warning is given if the CRS is unknown or when the CRS is longitude/latitude but the coordinates do not match that
global	logical. If TRUE, the method tests if the raster covers all longitudes (from -180 to 180 degrees) such that the extreme columns are in fact adjacent

Value

logical

Examples

```
r <- rast()
is.lonlat(r)
is.lonlat(r, global=TRUE)

crs(r) <- ""
is.lonlat(r)
is.lonlat(r, perhaps=TRUE, warn=FALSE)

crs(r) <- "+proj=lcc +lat_1=48 +lat_2=33 +lon_0=-100 +ellps=WGS84"
is.lonlat(r)
```

is.valid

Check polygon validity

Description

Check the validity of polygons

Usage

```
## S4 method for signature 'SpatVector'
is.valid(x, messages=FALSE)
```

Arguments

x	SpatVector
messages	logical. If TRUE the error messages are returned

Value

logical

Examples

```
w <- vect("POLYGON ((0 -5, 10 0, 10 -10, 0 -5))")
is.valid(w)

w <- vect("POLYGON ((0 -5, 10 0, 10 -10, 4 -2, 0 -5))")
is.valid(w)
is.valid(w, TRUE)

plot(w)
points(cbind(4.54, -2.72), cex=2, col="red")

# invalid polygon
#w <- vect("POLYGON ((0 -5, 10 0, 10 -10, 4 -2))")
#is.valid(w)
```

lapp

Apply a function to layers of a SpatRaster, or sub-datasets of a SpatRasterDataset

Description

Apply a function to a SpatRaster, using layers as arguments.

The number of arguments in function fun must match the number of layers in the SpatRaster (or the number of sub-datasets in the SpatRasterDataset). For example, if you want to multiply two layers, you could use this function: fun=function(x,y){return(x*y)} percentage: fun=function(x,y){return(100 * x / y)}. If you combine three layers you could use fun=function(x,y,z){return((x + y) * z)}

Before you use the function, test it to make sure that it is vectorized. That is, it should work for vectors longer than one, not only for single numbers. The function must return the same number of elements as its input vectors, or multiples of that. Also make sure that the function is NA-proof: it should return the same number of values when some or all input values are NA. And the function must return a vector or a matrix, not a data.frame.

Use [app](#) for summarize functions such as sum, that take any number of arguments; and [tapp](#) to do so for groups of layers.

Usage

```
## S4 method for signature 'SpatRaster'
lapp(x, fun, ..., usenames=FALSE, filename="", overwrite=FALSE, wopt=list())

## S4 method for signature 'SpatRasterDataset'
lapp(x, fun, ..., recycle=FALSE, filename="", overwrite=FALSE, wopt=list())
```


Arguments

x	SpatRaster or SpatRasterDataset
fun	a function that takes a vector and can be applied to each cell of x
...	additional arguments to be passed to fun
usenames	logical. Use the layer names to match the function arguments? If FALSE matching is by position
recycle	logical. Recycle layers to match the subdataset with the largest number of layers
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

Note

Use [sapp](#) or [lapply](#) to apply a function that takes a SpatRaster as argument to each layer of a SpatRaster (that is rarely necessary).

See Also

[app](#), [tapp](#), [math](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra")) + 1
ss <- s[[2:1]]

fvi <- function(x, y){ (x - y) / (x + y) }
x <- lapp(ss, fun=fvi )

# which is the same as supplying the layers to "fun"
# in some cases this will be much faster
y <- fvi(s[[2]], s[[1]])

f2 <- function(x, y, z){ (z - y + 1) / (x + y + 1) }
p1 <- lapp(s, fun=f2 )

p2 <- lapp(s[[1:2]], f2, z=200)

# the usenames argument

fvi2 <- function(red, green){ (red - green) / (red + green) }
names(s)
x1 <- lapp(s[[1:2]], fvi2, usenames=TRUE)
x2 <- lapp(s[[2:1]], fvi2, usenames=TRUE)
# x1 and x2 are the same, despite the change in the order of the layers
# x4 is also the same, but x3 is not
```

```
x3 <- lapp(s[[2:1]], fvi2, usenames=FALSE)
x4 <- lapp(s, fvi2, usenames=TRUE)

# while this would fail because
# there are too many layers in s
# x5 <- lapp(s, fvi2, usenames=FALSE)

pairs(c(x1, x2, x3, x4))

## SpatRasterDataset
x <- sds(s, s[[1]]+50)
lapp(x, function(x, y) x/y, recycle=TRUE)
```

linearUnits

Linear units of the coordinate reference system

Description

Get the linear units of the coordinate reference system (crs) of a SpatRaster or SpatVector expressed in m. The value returned is used internally to transform area and perimeter measures to meters. The value returned for longitude/latitude crs is zero.

Usage

```
## S4 method for signature 'SpatRaster'
linearUnits(x)

## S4 method for signature 'SpatVector'
linearUnits(x)
```

Arguments

x SpatRaster or SpatVector

Value

numeric (meter)

See Also

[crs](#)

Examples

```
x <- rast()
crs(x) <- ""
linearUnits(x)

crs(x) <- "+proj=longlat +datum=WGS84"
linearUnits(x)

crs(x) <- "+proj=utm +zone=1 +units=cm"
linearUnits(x)

crs(x) <- "+proj=utm +zone=1 +units=km"
linearUnits(x)

crs(x) <- "+proj=utm +zone=1 +units=us-ft"
linearUnits(x)
```

lines	<i>Add SpatVector data to a map</i>
-------	-------------------------------------

Description

Add SpatVector data to a plot (map) with points, lines, or polys.

These are simpler alternatives for `plot(x, add=TRUE)`

Usage

```
## S4 method for signature 'SpatVector'
points(x, col, cex=1, pch=20, ...)

## S4 method for signature 'SpatVector'
lines(x, y=NULL, col, lwd=1, lty=1, arrows=FALSE, ...)

## S4 method for signature 'SpatVector'
polys(x, col, border="black", lwd=1, lty=1, ...)

## S4 method for signature 'SpatExtent'
points(x, col, ...)

## S4 method for signature 'SpatExtent'
lines(x, col, ...)
```

Arguments

x	SpatVector or SpatExtent
y	missing or SpatVector. If both x and y have point geometry and the same number of rows, lines are drawn between pairs of points

col	character. Colors
border	character. color(s) of the polygon borders. Use NULL or NA to not draw a border
cex	numeric. point size magnifier. See par
pch	positive integer, line type. See points
lwd	numeric, line-width. See par
lty	positive integer, line type. See par
arrows	logical. If TRUE and y is a SpatVector, arrows are drawn instead of lines. See ?arrows for additional arguments
...	additional graphical arguments such as lwd, cex and pch

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

r <- rast(v)
values(r) <- 1:ncell(r)
plot(r)
lines(v)
points(v)
```

makeTiles

Make tiles

Description

Divide a SpatRaster into "tiles". The cell of another SpatRaster (normally with a much lower resolution) are used to define the tiles.

Usage

```
## S4 method for signature 'SpatRaster'
makeTiles(x, y, filename="tile_.tif", ...)
```

Arguments

x	SpatRaster
y	SpatRaster or SpatVector
filename	character. Output filename template. Filenames will be altered by adding the tilenumber for each tile
...	additional arguments for writing files as in writeRaster

Value

character (filenames)

Examples

```
r <- rast(ncols=100, nrows=100)
values(r) <- 1:ncell(r)
x <- rast(ncols=2, nrows=2)
filename <- paste0(tempfile(), "_tif")
ff <- makeTiles(r, x, filename)
```

mask

*Mask values in a SpatRaster***Description**

Create a new SpatRaster that has the same values as SpatRaster x, except for the cells that are NA (or another maskvalue) in another SpatRaster (the 'mask'), or not covered by a SpatVector. These cells become NA (or another updatevalue).

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
mask(x, mask, inverse=FALSE, maskvalues=NA,
      updatevalue=NA, filename="", ...)

## S4 method for signature 'SpatRaster,SpatVector'
mask(x, mask, inverse=FALSE, updatevalue=NA,
      touches=TRUE, filename="", ...)
```

Arguments

x	SpatRaster
mask	SpatRaster
inverse	logical. If TRUE, areas on mask that are <i>_not_</i> the maskvalue are masked
maskvalues	numeric. The value(s) in mask that indicates the cells of x that should become updatevalue (default = NA)
updatevalue	numeric. The value that cells of x should become if they are not covered by mask (and not NA)
touches	logical. If TRUE, all cells touched by lines or polygons will be masked, not just those on the line render path, or whose center point is within the polygon
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

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

```

r <- rast(ncols=10, nrows=10)
m <- rast(ncols=10, nrows=10)
values(r) <- 1:100
set.seed(1965)
x <- round(3 * runif(ncell(r)))
x[x==0] <- NA
values(m) <- x
mr <- mask(r, m)

```

match

Value matching for SpatRasters

Description

match returns a SpatRaster with the position of the matched values. The cell values are the index of the table argument.

%in% returns a 0/1 (FALSE/TRUE) SpatRaster indicating if the cells values were matched or not.

Usage

```
match(x, table, nomatch = NA_integer_, incomparables = NULL)
```

```
x %in% table
```

Arguments

x	SpatRaster
table	vector of the values to be matched against
nomatch	the value to be returned in the case when no match is found. Note that it is coerced to integer
incomparables	a vector of values that cannot be matched. Any value in x matching a value in this vector is assigned the nomatch value. For historical reasons, FALSE is equivalent to NULL

Value

SpatRaster

See Also

[app](#), [match](#)

Examples

```
r <- rast(nrows=10, ncols=10)
values(r) <- 1:100
m <- match(r, c(5:10, 50:55))
n <- r %in% c(5:10, 50:55)
```

math

*Arithmetic, logical and general mathematical methods***Description**

Standard operators and mathematical methods for computations with `SpatRaster` objects. Computations are local (applied on a cell by cell basis). If multiple `SpatRaster` objects are used, these must have the same extent and resolution. These have been implemented:

Arith: +, -, *, /, ^, %%, %/ %

Compare: ==, !=, >, <, <=, >=, is.na, is.nan, is.finite, is.infinite

The terra package does not distinguish between NA (not available) and NaN (not a number). In most cases this state is represented by NaN.

Logical: !, &, |, isTRUE, isFALSE

Summary: max, min, range, prod, sum, any, all

Math: abs, sign, sqrt, ceiling, floor, trunc, cummax, cummin, cumprod, cumsum, log, log10, log2, log1p, acos, acosh

The following methods have been implemented for **SpatExtent**: round, floor, ceil, ==, for (**SpatExtent, SpatExtent**): ==, +, -, and for (**SpatExtent, numeric**): +, -, *, /, %%

Usage

```
## S4 method for signature 'SpatRaster'
log(x, base=exp(1))
```

Arguments

x	SpatRaster
base	a positive or complex number: the base with respect to which logarithms are computed

Value

SpatRaster or SpatExtent

seealso

[ifel](#) to conveniently combine operations and [app](#) to use mathematical functions not implemented by the package.

Examples

```

r1 <- rast(ncols=10, nrows=10)
v <- runif(ncell(r1))
v[10:20] <- NA
values(r1) <- v
r2 <- rast(r1)
values(r2) <- 1:ncell(r2) / ncell(r2)
r3 <- r1 + r2
r2 <- r1 / 10
r3 <- r1 * (r2 - 1 / r2)

b <- c(r1, r2, r3)
b2 <- b * 10
s <- sqrt(b2)
round(s, 1)

max(s)
max(s, na.rm=TRUE)

x <- is.na(s)

y <- which.max(s)

### SpatExtent methods
x <- ext(0.1, 2.2, 0, 3)
y <- ext(-2, 1, -2,2)
# union
x + y
# intersection
x * y

e <- x
e
e * 2
e / 2
e + 1
e - 1

```

 mem

Memory available and needed

Description

mem_info prints the amount of RAM that is required and available to process a SpatRaster.

free_RAM returns the amount of RAM that is available

Usage

```
mem_info(x, n=1)
```

```
free_RAM()
```

Arguments

x SpatRaster
n positive integer. The number of copies of x that are needed

Value

free_RAM returns the amount of available RAM in kilobytes

Examples

```
mem_info(rast())
```

```
free_RAM()
```

merge	<i>Merge SpatRaster or SpatExtent objects, or a SpatVector with a data.frame</i>
-------	--

Description

Merge SpatRasters to form a new SpatRaster object with a larger spatial extent. If objects overlap, the values get priority in the same order as the arguments. See [classify](#) to merge a SpatRaster and a data.frame. You can also merge SpatExtent objects.

There is also a method for merging SpatVector with a data.frame; that is, to join the data.frame to the attribute table of the SpatVector..

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'  
merge(x, y, ..., filename="", overwrite=FALSE, wopt=list())
```

```
## S4 method for signature 'SpatRasterCollection,missing'  
merge(x, filename="", ...)
```

```
## S4 method for signature 'SpatExtent,SpatExtent'  
merge(x, y, ...)
```

```
## S4 method for signature 'SpatVector,data.frame'  
merge(x, y, ...)
```

Arguments

x	SpatRaster or SpatExtent
y	object of same class as x
...	if x is a SpatRaster: additional objects of the same class as x. If x is a SpatRasterCollection: options for writing files as in writeRaster . If x is a SpatVector, the same arguments as in merge
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Details

The SpatRaster objects must have the same origin and spatial resolution. In areas where the SpatRaster objects overlap, the values of the SpatRaster that is last in the sequence of arguments will be retained.

Value

SpatRaster or SpatExtent

Note

You can use `merge` with `do.call` to merge a list of SpatRasters (see example). But note that if the list is named, these names are used by `merge`. So if all elements are named, there should be one element with a SpatRaster called `x` and another one called `y`. For example with `names(x)[1:2] <- c("x" "y")`. You can also removed the names of the the first two elements (assuming these are SpatRasters) with `names(x)[1:2] <- ""`.

See Also

[mosaic](#)

Examples

```
x <- rast(xmin=-110, xmax=-80, ymin=40, ymax=70, ncols=30, nrows=30)
y <- rast(xmin=-85, xmax=-55, ymax=60, ymin=30, ncols=30, nrows=30)
z <- rast(xmin=-60, xmax=-30, ymax=50, ymin=20, ncols=30, nrows=30)
values(x) <- 1:ncell(x)
values(y) <- 1:ncell(y)
values(z) <- 1:ncell(z)

m1 <- merge(x, y, z)
m2 <- merge(z, y, x)
m3 <- merge(y, x, z)

# if you have many SpatRasters make a SpatRasterCollection from a list
rlist <- list(x, y, z)
rsrc <- src(rlist)
```

```

m <- merge(rsrc)

## SpatVector with data.frame
f <- system.file("ex/lux.shp", package="terra")
p <- vect(f)
dfr <- data.frame(District=p$NAME_1, Canton=p$NAME_2, Value=round(runif(length(p), 100, 1000)))
dfr <- dfr[1:5, ]
pm <- merge(p, dfr, all.x=TRUE, by.x=c('NAME_1', 'NAME_2'), by.y=c('District', 'Canton'))
pm
values(pm)

```

modal	<i>modal value</i>
-------	--------------------

Description

Compute the mode for each cell across the layers of a `SpatRaster`. The mode, or modal value, is the most frequent value in a set of values.

Usage

```

## S4 method for signature 'SpatRaster'
modal(x, ..., ties="first", na.rm=FALSE, filename="", overwrite=FALSE, wopt=list())

```

Arguments

x	<code>SpatRaster</code>
...	additional argument of the same type as x or numeric
ties	character. Indicates how to treat ties. Either "random", "lowest", "highest", "first", or "NA"
na.rm	logical. If TRUE, NA values are ignored. If FALSE, NA is returned if x has any NA values
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

`SpatRaster`

Examples

```

r <- rast(system.file("ex/logo.tif", package="terra"))
r <- c(r/2, r, r*2)
m <- modal(r)

```

mosaic

mosaic SpatRasters

Description

mosaic SpatRasters to form a new SpatRaster object with a larger spatial extent. Unlike with [merge](#), values on overlapping areas are averaged.

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'  
mosaic(x, y, ..., fun="mean", filename="", overwrite=FALSE, wopt=list())
```

```
## S4 method for signature 'SpatRasterCollection,missing'  
mosaic(x, fun="mean", filename="", ...)
```

Arguments

x	SpatRaster
y	object of same class as x
...	additional SpatRasters
fun	character. One of "sum", "mean", "median", "min", "max"
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Details

The SpatRaster objects must have the same origin and spatial resolution. In areas where the SpatRaster objects overlap, the values of the SpatRaster that is last in the sequence of arguments will be retained.

Value

SpatRaster

See Also

[merge](#)

Examples

```
x <- rast(xmin=-110, xmax=-80, ymin=40, ymax=70, ncols=30, nrows=30)
y <- rast(xmin=-85, xmax=-55, ymax=60, ymin=30, ncols=30, nrows=30)
z <- rast(xmin=-60, xmax=-30, ymax=50, ymin=20, ncols=30, nrows=30)
values(x) <- 1:ncell(x)
values(y) <- 1:ncell(y)
values(z) <- 1:ncell(z)

m1 <- mosaic(x, y, z)
m2 <- mosaic(z, y, x)

# if you have many SpatRasters make a SpatRasterCollection from a list
rlist <- list(x, y, z)
rsrc <- src(rlist)

m <- mosaic(rsrc)
```

na.omit

na.omit for SpatVector

Description

Remove empty geometries and/or records that are NA from a SpatVector.

Usage

```
## S4 method for signature 'SpatVector'
na.omit(object, field=NA, geom=FALSE)
```

Arguments

object	SpatVector
field	character or NA. If NA, missing values in the attributes are ignored. Other values are either one or more field (variable) names, or "" to consider all fields
geom	logical. If TRUE empty geometries are removed

Value

SpatVector

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v$test <- c(1,2,NA)
nrow(v)
x <- na.omit(v, "test")
nrow(x)
```

NAflag*Set the NA flag*

Description

The main purpose of this method is to allow correct reading of a `SpatRaster` that is based on a file that has an incorrect NA flag. The file is not changed, but flagged value is set to NA when values are read from the file ("lazy evaluation"). In contrast, if the values are in memory the change is made immediately.

To change values, it is generally better to use `classify`

Usage

```
## S4 method for signature 'SpatRaster'  
NAflag(x)  
  
## S4 replacement method for signature 'SpatRaster'  
NAflag(x)<-value
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>value</code>	numeric. The value to be interpreted as NA; set this before reading the values from the file. This can be a single value, or multiple values, one for each data source (file / subdataset)

Value

none or numeric

See Also

`classify`

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))[[1]]  
NAflag(s) <- 255  
plot(s)  
NAflag(s)
```

names	<i>Names of Spat* objects</i>
-------	-------------------------------

Description

Get or set the names of the layers of a SpatRaster or the attributes of a SpatVector. With longnames you can get or set the "long names" of a SpatRaster or SpatRasterDataset.

For a SpatRaster, you can also get/set a variable name or long name (one per data source)

Usage

```
## S4 method for signature 'SpatRaster'
names(x)

## S4 replacement method for signature 'SpatRaster'
names(x)<-value

## S4 method for signature 'SpatRaster'
varnames(x)

## S4 replacement method for signature 'SpatRaster'
varnames(x)<-value

## S4 method for signature 'SpatRaster'
longnames(x)

## S4 replacement method for signature 'SpatRaster'
longnames(x)<-value

## S4 method for signature 'SpatRasterDataset'
names(x)

## S4 replacement method for signature 'SpatRasterDataset'
names(x)<-value

## S4 method for signature 'SpatRasterDataset'
varnames(x)

## S4 replacement method for signature 'SpatRasterDataset'
varnames(x)<-value

## S4 method for signature 'SpatRasterDataset'
longnames(x)

## S4 replacement method for signature 'SpatRasterDataset'
```

```
longnames(x)<-value

## S4 method for signature 'SpatVector'
names(x)

## S4 replacement method for signature 'SpatVector'
names(x)<-value
```

Arguments

x	SpatRaster, SpatRasterDataset, or SpatVector
value	character (vector)

Value

character

Note

terra enforces neither unique nor valid names. See [make.unique](#) to create unique names and `{make.names}` to make syntactically valid names.

Examples

```
s <- rast(ncols=5, nrows=5, nlyrs=3)
nlyr(s)
names(s)
names(s) <- c("a", "b", "c")
names(s)

# space is not valid
names(s)[2] <- "hello world"
names(s)

# two invalid names
names(s) <- c("a", " a ", "3")
names(s)

# SpatVector names
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
names(v)
names(v) <- paste0(substr(names(v), 1, 2), "_", 1:ncol(v))
names(v)
```

nearest	<i>nearby geometries</i>
---------	--------------------------

Description

Identify geometries that are near to each other. Either get the index of all geometries within a certain distance, or the k nearest neighbors, or (with nearest) get the nearest points between two geometries.

Usage

```
## S4 method for signature 'SpatVector'
nearby(x, y=NULL, distance=0, k=1, centroids=TRUE, symmetrical=TRUE)
```

```
## S4 method for signature 'SpatVector'
nearest(x, y, pairs=FALSE, centroids=TRUE, lines=FALSE)
```

Arguments

x	SpatVector
y	SpatVector or NULL
distance	numeric. maximum distance
k	positive integer. number of neighbors. Ignored if distance > 0
centroids	logical. Should the centroids of polygons be used?
symmetrical	logical. If TRUE, a near pair is only included once. That is, if geometry 1 is near to geometry 3, the implied nearness between 3 and 1 is not reported. Ignored if k neighbors are returned
pairs	logical. If TRUE pairwise nearest points are returned (only relevant when using at least one SpatVector of lines or polygons)
lines	logical. If TRUE lines between the nearest points instead of (the nearest) points

Value

matrix

See Also

[relate](#), [adjacent](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
nearby(v, distance=12000)
```

options

Options

Description

Class and methods for showing and setting general options for terra.

Usage

```
terraOptions(...)
```

Arguments

... option names and values (see Details). Or missing, to show the current options

Details

The following options are available.

memfrac - value between 0.1 and 0.9 (larger values give a warning). The fraction of RAM that may be used by the program.

tempdir - directory where temporary files are written. The default what is returned by tempdir().

datatype - default data type. See [writeRaster](#)

todisk - logical. If TRUE write all raster data to disk (temp file if no file name is specified). For debugging.

progress - non-negative integer. A progress bar is shown if the number of chunks in which the data is processed is larger than this number. No progress bar is shown if the value is zero

verbose - logical. If TRUE debugging info is printed for some functions

Examples

```
terraOptions()  
terraOptions(memfrac=0.5, tempdir = "c:/temp")  
terraOptions(progress=10)  
terraOptions()
```

origin	<i>Origin</i>
--------	---------------

Description

Get or set the coordinates of the point of origin of a SpatRaster. This is the point closest to (0, 0) that you could get if you moved towards that point in steps of the x and y resolution.

Usage

```
## S4 method for signature 'SpatRaster'
origin(x)

## S4 replacement method for signature 'SpatRaster'
origin(x)<-value
```

Arguments

x	SpatRaster
value	numeric vector of length 1 or 2

Value

A vector of two numbers (x and y coordinates)

Examples

```
r <- rast(xmin=-0.5, xmax = 9.5, ncols=10)
origin(r)
origin(r) <- c(0,0)
r
```

pairs	<i>Pairs plot (matrix of scatterplots)</i>
-------	--

Description

Pair plots of layers in a SpatRaster. This is a wrapper around graphics function [pairs](#).

Usage

```
## S4 method for signature 'SpatRaster'
pairs(x, hist=TRUE, cor=TRUE, use="pairwise.complete.obs", maxcells=100000, ...)
```

Arguments

x	SpatRaster
hist	logical. If TRUE a histogram of the values is shown on the diagonal
cor	logical. If TRUE the correlation coefficient is shown in the upper panels
use	argument passed to the cor function
maxcells	integer. Number of pixels to sample from each layer of a large SpatRaster
...	additional arguments (graphical parameters)

See Also

[boxplot](#), [hist](#)

Examples

```
r <-rast(system.file("ex/elev.tif", package="terra"))
s <- c(r, 1/r, sqrt(r))
names(s) <- c("elevation", "inverse", "sqrt")
pairs(s)

# to make individual histograms:
hist(r)
# or scatter plots:
plot(s[[1]], s[[2]])
```

patches

Detect patches (clumps) of cells

Description

Detect patches (clumps). Patches are groups of cells that are surrounded by cells that are NA. Set `zeroAsNA` to TRUE to also identify patches separated by cells with values of zero.

Usage

```
## S4 method for signature 'SpatRaster'
patches(x, directions=4, zeroAsNA=FALSE, filename="", ...)
```

Arguments

x	SpatRaster
directions	integer indicating which cells are considered adjacent. Should be 8 (Queen's case) or 4 (Rook's case)
zeroAsNA	logical. If TRUE treat cells that are zero as if they were NA
filename	character. Output filename
...	options for writing files as in writeRaster

Value

SpatRaster. Cell values are either a patch number

See Also

[focal](#), [boundaries](#)

Examples

```
r <- rast(nrows=18, ncols=36, xmin=0)
r[1:2, 5:8] <- 1
r[5:8, 2:6] <- 1
r[7:12, 22:36] <- 1
r[15:16, 18:29] <- 1
p <- patches(r)

r <- rast(nrows=10, ncols=10, xmin=0)
r[] <- 0
r[3, 3] <- 10
r[4, 4] <- 10
r[5, 5:8] <- 12
r[6, 6:9] <- 12

# remove zeros if need be with zeroAsNA

p4 <- patches(r, zeroAsNA=TRUE)
p8 <- patches(r, 8, zeroAsNA=TRUE)

# patches for different values
# remove zeros
rr <- classify(r, cbind(0, NA))
# first make layers for each value
s <- segregate(rr, keep=TRUE, other=NA)
p <- patches(s)
```

perim

Perimeter or length

Description

This method returns the length of lines or the perimeter of polygons.

Usage

```
## S4 method for signature 'SpatVector'
perim(x)
```

Arguments

x SpatVector

Value

numeric (m)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
perim(v)
```

persp

Perspective plot

Description

Perspective plot of a SpatRaster. This is an implementation of a generic function in the graphics package.

Usage

```
## S4 method for signature 'SpatRaster'
persp(x, maxcells=100000, ...)
```

Arguments

x SpatRaster. Only the first layer is used

maxcells integer > 0. Maximum number of cells to use for the plot. If maxpixels < ncell(x), spatSample(method="regular") is used before plotting

... Any argument that can be passed to [persp](#) (graphics package)

See Also

[persp](#), [contour](#), [plot](#)

Examples

```
r <- rast(system.file("ex/elev.tif", package="terra"))
persp(r)
```

plot

*Make a map***Description**

Plot the values of a `SpatRaster` or `SpatVector` to make a map. See [lines](#) to add a `SpatVector` to an existing map.

Usage

```
## S4 method for signature 'SpatRaster,numeric'
plot(x, y=1, col, type, mar=NULL, legend=TRUE, axes=TRUE, plg=list(),
     pax=list(), maxcell=500000, smooth=FALSE, range=NULL, levels=NULL, fun=NULL,
     colNA=NULL, alpha=NULL, reset=FALSE, ...)

## S4 method for signature 'SpatRaster,missing'
plot(x, y, maxcell=500000, main, mar=NULL, nc, nr, maxnl=16, ...)

## S4 method for signature 'SpatVector,character'
plot(x, y, col, type, mar=NULL, legend=TRUE,
     add=FALSE, axes=!add, main=y,
     plg=list(), pax=list(), nr, nc, ...)

## S4 method for signature 'SpatVector,numeric'
plot(x, y, ...)

## S4 method for signature 'SpatVector,missing'
plot(x, y, ...)

## S4 method for signature 'SpatExtent,missing'
plot(x, y, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>y</code>	missing or positive integer or name indicating the layer(s) to be plotted
<code>col</code>	character. Colors
<code>type</code>	character. Type of map/legend. One of "continuous", "classes", or "interval"
<code>mar</code>	numeric vector of length 4 to set the margins of the plot (to make space for the legend). The default is (3.1, 3.1, 2.1, 7.1) for a single plot with a legend and (3.1, 3.1, 2.1, 2.1) otherwise. Use <code>mar=NA</code> to not set the margins
<code>legend</code>	logical or character. If not <code>FALSE</code> a legend is drawn. The character value can be used to indicate where the legend is to be draw. For example "topright" or "bottomleft". Use <code>plg</code> for more refined placement (<code>SpatVector</code> data only)
<code>axes</code>	logical. Draw axes?

<code>plg</code>	list with parameters for drawing the legend. See the arguments for legend
<code>pax</code>	list with parameters for drawing axes. See the arguments for axis
<code>maxcell</code>	positive integer. Maximum number of cells to use for the plot
<code>smooth</code>	logical. If TRUE the cell values are smoothed (for continuous legend)
<code>range</code>	numeric. minimum and maximum values to be used for the continuous legend
<code>levels</code>	character. labels to be used for the classes legend
<code>fun</code>	function to be called after plotting each <code>SpatRaster</code> layer to add something to each map (such as text, legend, lines). For example, with <code>SpatVector v</code> , you could do <code>fun=function() lines(v)</code> . The function may have one argument, representing the the layer that is plotted (1 to the number of layers)
<code>colNA</code>	character. color for the NA values
<code>alpha</code>	Either a single numeric between 0 and 1 to set the transparency for all colors (0 is transparent, 1 is opaque) or a <code>SpatRaster</code> with values between 0 and 1 to set the transparency by cell. To set the transparency for a given color, set it to the colors directly
<code>nc</code>	positive integer. Optional. The number of columns to divide the plotting device in (when plotting multiple layers)
<code>nr</code>	positive integer. Optional. The number of rows to divide the plotting device in (when plotting multiple layers)
<code>main</code>	character. Main plot titles (one for each layer to be plotted)
<code>maxnl</code>	positive integer. Maximum number of layers to plot (for a multi-layer object)
<code>add</code>	logical. If TRUE add the object to the current plot
<code>reset</code>	logical. If TRUE add the margins (see argument <code>mar</code>) are reset to what they were before calling <code>plot</code> ; doing so may affect the display of additional objects that are added to the map (e.g. with lines)
<code>...</code>	arguments passed to <code>plot("SpatRaster", "numeric")</code> and additional graphical arguments

See Also

[points](#), [lines](#), [polys](#), [image](#), [scatterplot](#), [sbar](#)

Examples

```
## raster
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
plot(r)

plot(r, type="interval")

e <- c(6.3, 6.35, 49.9, 50.1)
plot(r, plg=list(ext=e, title="Title\n", title.cex=1.25), pax=list(sides=1:2))
```



```

d <- classify(r, c(100,200,300,400,500,600))
plot(d, type="classes")

plot(d, type="interval", breaks=1:5)
plot(d, type="interval", breaks=c(1,4,5), plg=list(legend=c("1-4", "4-5")))
plot(d, type="classes", plg=list(legend=c("Mr", "Xx", "As", "Zx", "Bb"), x="bottomright"))

x <- trunc(r/200)
levels(x) <- c("earth", "wind", "fire")
plot(x, plg=list(x="topright"),mar=c(2,2,2,2))

# two plots with the same legend
dev.new(width=6, height=4, noRStudioGD = TRUE)
par(mfrow=c(1,2))
plot(r, range=c(50,600))
plot(r/2, range=c(50,600))

# as you only need one legend:
par(mfrow=c(1,2))
plot(r, range=c(50,600), mar=c(4, 3, 4, 3), plg=list(shrink=0.9, cex=.8),
pax=list(sides=1:2, cex.axis=.6))
#text(182500, 335000, "Two maps, one plot", xpd=NA)
plot(r/2, range=c(50,600), mar=c(4, 2, 4, 4), legend=FALSE,
pax=list(sides=c(1,4), cex.axis=.6))

## multi-layer with RGB
s <- rast(system.file("ex/logo.tif", package="terra"))
s
plot(s)
# remove RGB
plot(s*1)
# or use layers
plot(s, 1)
plot(s, 1:3)

## vector

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)

plot(v)

plot(v, 2, pax=list(sides=1:2), plg=list(x=6.2, y=50.2, cex=1.2))

plot(v, 4, pax=list(sides=1:2), plg=list(x=6.2, y=50.2, ncol=2), main="")

plot(v, 1, plg=list(x=5.9, y=49.37, horiz=TRUE, cex=1.1), main="", mar=c(5,2,0.5,0.5))

plot(v, density=1:12, angle=seq(18, 360, 20), col=rainbow(12))

plot(v, "NAME_2", col=rainbow(12), border=c("gray", "blue"), lwd=3, type="classes")

```

```

plot(v, "AREA", type="interval", breaks=3, mar=c(3.1, 3.1, 2.1, 3.1),
     plg=list(x="topright"), main="")

plot(v, "AREA", type="interval", breaks=c(0,200,250,350), mar=c(2,2,2,2),
     plg=list(legend=c("<200", "200-250", ">250"), cex=1,
             bty="o", x=6.4, y=50.125, box.lwd=2, bg="light yellow", title="My Legend"))

```

plotRGB

Red-Green-Blue plot of a multi-layered SpatRaster

Description

Make a Red-Green-Blue plot based on three layers in a `SpatRaster`. The layers (sometimes referred to as "bands" because they may represent different bandwidths in the electromagnetic spectrum) are combined such that they represent the red, green and blue channel. This function can be used to make "true" (or "false") color images from Landsat and other multi-spectral satellite images.

Usage

```

## S4 method for signature 'SpatRaster'
plotRGB(x, r=1, g=2, b=3, a=NULL, scale, maxcell=500000, mar=0,
        stretch=NULL, ext=NULL, smooth=FALSE, colNA="white", alpha, bgamma,
        addfun=NULL, zlim=NULL, zlimcol=NULL, axes=FALSE, xlab="", ylab="",
        asp=NULL, add=FALSE, interpolate, ...)

```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>r</code>	integer. Index of the Red channel, between 1 and <code>nlyr(x)</code>
<code>g</code>	integer. Index of the Green channel, between 1 and <code>nlyr(x)</code>
<code>b</code>	integer. Index of the Blue channel, between 1 and <code>nlyr(x)</code>
<code>a</code>	integer. Index of the alpha (transparency) channel, between 1 and <code>nlyr(x)</code> . If not <code>NULL</code> , argument <code>alpha</code> is ignored
<code>scale</code>	integer. Maximum (possible) value in the three channels. Defaults to 255 or to the maximum value of <code>x</code> if that is known and larger than 255
<code>maxcell</code>	integer > 0. Maximum number of pixels to use
<code>mar</code>	numeric vector recycled to length 4 to set the margins of the plot. Use <code>mar=NULL</code> or <code>mar=NA</code> to not set the margins
<code>stretch</code>	character. Option to stretch the values to increase contrast: "lin" (linear) or "hist" (histogram)
<code>ext</code>	An <code>SpatExtent</code> object to zoom in to a region of interest (see <code>draw</code>)
<code>smooth</code>	logical. If <code>TRUE</code> , smooth the image when drawing to get the appearance of a higher spatial resolution

colNA	color for the background (NA values)
alpha	transparency. Integer between 0 (transparent) and 255 (opaque)
bgalpha	Background transparency. Integer between 0 (transparent) and 255 (opaque)
addfun	Function to add additional items such as points or polygons to the plot (map). See plot
zlim	numeric vector of length 2. Range of values to plot (optional)
zlimcol	If NULL the values outside the range of zlim get the color of the extremes of the range. If zlimcol has any other value, the values outside the zlim range get the color of NA values (see colNA)
axes	logical. If TRUE axes are drawn (and arguments such as main="title" will be honored)
xlab	character. Label of x-axis
ylab	character. Label of y-axis
asp	numeric. Aspect (ratio of x and y. If NULL, and appropriate value is computed to match data for the longitude/latitude coordinate reference system, and 1 for planar coordinate reference systems)
add	logical. If TRUE add values to current plot
interpolate	logical. Do not use, to be removed
...	graphical parameters as in plot or rasterImage

See Also

[plot](#), [RGB](#)

Examples

```
b <- rast(system.file("ex/logo.tif", package="terra"))
plotRGB(b)
plotRGB(b, mar=c(2,2,2,2))
plotRGB(b, 3, 2, 1)

b[1000:2000] <- NA
plotRGB(b, 3, 2, 1, stretch='hist')
```

predict

Spatial model predictions

Description

Make a SpatRaster object with predictions from a fitted model object (for example, obtained with `glm` or `randomForest`). The first argument is a SpatRaster object with the predictor variables. The [names](#) in the Raster object should exactly match those expected by the model. Any regression like model for which a `predict` method has been implemented (or can be implemented) can be used.

This approach of using model predictions is commonly used in remote sensing (for the classification of satellite images) and in ecology, for species distribution modeling.

Usage

```
## S4 method for signature 'SpatRaster'
predict(object, model, fun=predict, ..., factors=NULL, const=NULL, na.rm=FALSE,
        index=NULL, cores=1, cpkgs=NULL, filename="", overwrite=FALSE, wopt=list())
```

Arguments

object	SpatRaster
model	fitted model of any class that has a "predict" method (or for which you can supply a similar method as fun argument. E.g. glm, gam, or randomForest
fun	function. The predict function that takes model as first argument. The default value is predict, but can be replaced with e.g. predict.se (depending on the type of model), or your own custom function
...	additional arguments for fun
const	data.frame. Can be used to add a constant value as a predictor variable so that you do not need to make a SpatRaster layer for it
factors	list with levels for factor variables. The list elements should be named with names that correspond to names in object such that they can be matched. This argument may be omitted for standard models such as "glm" as the predict function will extract the levels from the model object, but it is necessary in some other cases (e.g. cforest models from the party package)
na.rm	logical. If TRUE, cells with NA values in the predictors are removed from the computation. This option prevents errors with models that cannot handle NA values. In most other cases this will not affect the output. An exception is when predicting with a model that returns predicted values even if some (or all!) variables are NA
index	integer. To select subset of output variables
cores	positive integer. If cores > 1, a 'parallel' package cluster with that many cores is created and used
cpkgs	character. The package(s) that need to be loaded on the nodes to be able to run the model.predict function (see examples)
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

Examples

```
logo <- rast(system.file("ex/logo.tif", package="terra"))
names(logo) <- c("red", "green", "blue")
p <- matrix(c(48, 48, 48, 53, 50, 46, 54, 70, 84, 85, 74, 84, 95, 85,
             66, 42, 26, 4, 19, 17, 7, 14, 26, 29, 39, 45, 51, 56, 46, 38, 31,
```

```

22, 34, 60, 70, 73, 63, 46, 43, 28), ncol=2)

a <- matrix(c(22, 33, 64, 85, 92, 94, 59, 27, 30, 64, 60, 33, 31, 9,
  99, 67, 15, 5, 4, 30, 8, 37, 42, 27, 19, 69, 60, 73, 3, 5, 21,
  37, 52, 70, 74, 9, 13, 4, 17, 47), ncol=2)

xy <- rbind(cbind(1, p), cbind(0, a))

# extract predictor values for points
e <- extract(logo, xy[,2:3])

# combine with response (excluding the ID column)
v <- data.frame(cbind(pa=xy[,1], e[,-1]))

#build a model, here with glm
model <- glm(formula=pa~., data=v)

#predict to a raster
r1 <- predict(logo, model)

plot(r1)
points(p, bg='blue', pch=21)
points(a, bg='red', pch=21)

# logistic regression
model <- glm(formula=pa~., data=v, family="binomial")
r1log <- predict(logo, model, type="response")

# use a modified function to get the probability and standard error
# from the glm model. The values returned by "predict" are in a list,
# and this list needs to be transformed to a matrix

predfun <- function(model, data) {
  v <- predict(model, data, se.fit=TRUE)
  cbind(p=as.vector(v$fit), se=as.vector(v$se.fit))
}

r2 <- predict(logo, model, fun=predfun)

# principal components of a SpatRaster
# here using sampling to simulate an object too large
# to feed all its values to prcomp

sr <- values(spatSample(logo, 100, as.raster=TRUE))
pca <- prcomp(sr)

x <- predict(logo, pca)
plot(x)

## parallelization
## Not run:
## simple case with GLM
model <- glm(formula=pa~., data=v)

```

```

p <- predict(logo, model, cores=2)

## The above does not work with a model from a contributed
## package, as the package needs to be loaded in each core.
## Below are three approaches to deal with that

library(randomForest)
rfm <- randomForest(formula=pa~., data=v)

## approach 0 (not parallel)
rp0 <- predict(logo, rfm)

## approach 1, use the "cpkgs" argument
rp1 <- predict(logo, rfm, cores=2, cpkgs="randomForest")

## approach 2, write a custom predict function that loads the package
rfun <- function(mod, dat, ...) {
  library(randomForest)
  predict(mod, dat, ...)
}
rp2 <- predict(logo, rfm, fun=rfun, cores=2)

## approach 3, write a parallelized custom predict function
rfun <- function(mod, dat, ...) {
  ncls <- length(cls)
  nr <- nrow(dat)
  s <- split(dat, rep(1:ncls, each=ceiling(nr/ncls), length.out=nr))
  unlist( parallel::clusterApply(cls, s, function(x, ...) predict(mod, x, ...)) )
}

library(parallel)
cls <- parallel::makeCluster(2)
parallel::clusterExport(cls, c("rfm", "rfun", "randomForest"))
rp3 <- predict(logo, rfm, fun=rfun)
parallel::stopCluster(cls)

plot(c(rp0, rp1, rp2, rp3))

## End(Not run)

```

project

Change the coordinate reference system

Description

Change the coordinate reference system ("project") of a `SpatVector` or `SpatRaster`.

Usage

```
## S4 method for signature 'SpatVector'
project(x, y)

## S4 method for signature 'SpatRaster'
project(x, y, method, mask=FALSE, filename="", ...)
```

Arguments

x	SpatVector
y	if (x is a SpatRaster, the preferred approach is for y to be a SpatRaster as well, serving as a template for the geometry of the output SpatRaster. Alternatively, you can provide a character variable containing a textual coordinate reference system (crs). You can use the following formats to provide textual coordinate reference system (crs) definitions: WKT, PROJ.4 (e.g., +proj=longlat +datum=WGS84), or an EPSG code (e.g., "epsg:4326") to define the output coordinate reference system (crs). But note that when using PROJ.4 you now must use the WGS84 datum. Other datums are silently ignored. If x is a SpatVector, you can provide a crs definition as discussed above, or any other object from which such a crs can be extracted with crs
method	character. Method used for estimating the new cell values. One of: near: nearest neighbor. This method is fast, and it can be the preferred method if the cell values represent classes. It is not a good choice for continuous values. This is used by default if the first layer of x is categorical. bilinear: bilinear interpolation. This is the default if the first layer of x is numeric (not categorical). cubic: cubic interpolation. cubicspline: cubic spline interpolation.
mask	logical. If TRUE, mask out areas outside the input extent (see example with Robinson projection)
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatVector or SpatRaster

Note

User beware. Sadly, the PROJ.4 notation has been partly deprecated in the GDAL/PROJ library that is used by this function. You can still use this notation, but **only** with the the WGS84 datum. Other datums are silently ignored.

When printing a Spat* object the PROJ.4 notation is shown because it is the most concise and clear format available. However, internally a WKT representation is used (see [crs](#)).

Transforming (projecting) raster data is fundamentally different from transforming vector data. Vector data can be transformed and back-transformed without loss in precision and without changes in the values. This is not the case with raster data. In each transformation the values for the new cells are estimated in some fashion. Therefore, if you need to match raster and vector data for analysis, you should generally transform the vector data.

When using this method with a `SpatRaster`, the preferable approach is to provide a template `SpatRaster` as argument `y`. The template is then another raster dataset that you want your data to align with. If you do not have a template to begin with, you can do `project(x, crs)` and then manipulate the output to get the template you want. For example, where possible use whole numbers for the extent and resolution so that you do not have to worry about small differences in the future. You can use commands like `dim(z) = c(180, 360)` or `res(z) <- 100000`.

The output resolution should be similar to the input resolution, but there is not "correct" resolution in raster transformation; but it is not obvious what this resolution is if you are using lon/lat data that spans a large North-South extent.

See Also

[crs](#), [resample](#)

Examples

```
## SpatRaster
a <- rast(ncols=40, nrows=40, xmin=-110, xmax=-90, ymin=40, ymax=60,
          crs="+proj=longlat +datum=WGS84")
values(a) <- 1:ncell(a)
newcrs="+proj=lcc +lat_1=48 +lat_2=33 +lon_0=-100 +datum=WGS84"
b <- rast(ncols=94, nrows=124, xmin=-944881, xmax=935118, ymin=4664377, ymax=7144377, crs=newcrs)
w <- project(a, b)

## SpatVector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
crs <- "+proj=moll +lon_0=0 +x_0=0 +y_0=0 +ellps=WGS84 +datum=WGS84"
p <- project(v, crs)
p
```

quantile

Quantiles of spatial data

Description

Compute quantiles for each cell across the layers of a `SpatRaster`.

You can also use this method to compute the quantiles of the numeric variables of a `SpatVector`.

Usage

```
## S4 method for signature 'SpatRaster'
quantile(x, probs=seq(0, 1, 0.25), na.rm=FALSE, filename="", ...)

## S4 method for signature 'SpatVector'
quantile(x, probs=seq(0, 1, 0.25), ...)
```

Arguments

x	SpatRaster or SpatVector
probs	numeric vector of probabilities with values in [0,1]
na.rm	logical. If TRUE, NA's are removed from x before the quantiles are computed
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster with layers representing quantiles

See Also

[app](#)

Examples

```
r <- rast(system.file("ex/logo.tif", package="terra"))
r <- c(r/2, r, r*2)
q <- quantile(r)
q

# same but slower
# qa <- app(r, quantile)
```

rapp

Range-Apply

Description

Apply a function to a range of the layers of a SpatRaster that varies by cell. The range is specified for each cell one or two SpatRasters (arguments *first* and *last*). For either *first* or *last* you can use a numeric constant instead.

See [selectRange](#) to create a new SpatRaster by extracting one or more values starting at a cell-varying layer.

See [app](#) or [Summary-methods](#) if you want to apply a function to all cells (not a range), perhaps after making a [subset](#) of a SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
rapp(x, first, last, fun, ..., alllys=FALSE, fill=NA,
      clamp=FALSE, filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatRaster
first	SpatRaster or positive integer between 1 and nlyr(x), indicating the first layer in the range of layers to be considered
last	SpatRaster or positive integer between 1 and nlyr(x), indicating the last layer in the range to be considered
fun	function to be applied
...	additional arguments passed to fun
allys	logical. Should the values of all layers be passed to fun. The values outside of the range are set to fill
fill	numeric. The fill value for the the values outside of the range, for when alllys=TRUE
clamp	logical. If FALSE and the specified range is outside 1:nlyr(x) all cells are considered NA. Otherwise, the invalid part of the range is ignored
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also

[selectRange](#), [app](#), [Summary-methods](#), [lapp](#), [tapp](#)

Examples

```
r <- rast(ncols=9, nrows=9)
values(r) <- 1:ncell(r)
s <- c(r, r, r, r, r, r)
s <- s * 1:6
s[1:2] <- NA
start <- end <- rast(r)
start[] <- 1:3
end[] <- 4:6
a <- rapp(s, start, end, fun="mean")
b <- rapp(s, start, 2, fun="mean")

# cumsum from start to nlyr(x). return all layers
r <- rapp(s, start, nlyr(s), cumsum, alllys=TRUE, fill=0)
# return only the final value
rr <- rapp(s, start, nlyr(s), function(i) max(cumsum(i)))
```

 rast

 Create a *SpatRaster*

Description

Methods to create a *SpatRaster*. These objects can be created from scratch or from a file.

A *SpatRaster* represents a spatially referenced surface divided into three dimensional cells (rows, columns, and layers).

When a *SpatRaster* is created from a file, it does not load the cell (pixel) values into memory (RAM). It only reads the basic parameters that describe the *SpatRaster* such as the number of rows and columns and the coordinate reference system. The actual values will be read, perhaps in chunks – to avoid memory overflows – as needed.

Usage

```
## S4 method for signature 'character'
rast(x, subds=0, opts=NULL)

## S4 method for signature 'missing'
rast(x, nrows=180, ncols=360, nlyrs=1, xmin=-180, xmax=180,
      ymin=-90, ymax=90, crs, extent, resolution, vals, names)

## S4 method for signature 'SpatRaster'
rast(x, nlyrs=nlyr(x), names, vals, time=FALSE, props=FALSE)

## S4 method for signature 'matrix'
rast(x, type="", crs="", digits=6)

## S4 method for signature 'data.frame'
rast(x, type="", crs="", digits=6)

## S4 method for signature 'list'
rast(x)

## S4 method for signature 'SpatRasterDataset'
rast(x)

## S4 method for signature 'SpatVector'
rast(x, ...)

## S4 method for signature 'SpatExtent'
rast(x, ...)
```

Arguments

x filename (character), missing, *SpatRaster*, *SpatRasterDataset*, *SpatExtent*, *SpatVector*, matrix, array, list of *SpatRaster* objects. For other types it will be attempted

	to create a SpatRaster via (<code>as(x, "SpatRaster")</code>)
subds	positive integer or character to select a subdataset. If zero or "", all subdatasets are returned (if possible)
opts	character. GDAL dataset open options
nrows	positive integer. Number of rows
ncols	positive integer. Number of columns
nlyrs	positive integer. Number of layers
xmin	minimum x coordinate (left border)
xmax	maximum x coordinate (right border)
ymin	minimum y coordinate (bottom border)
ymax	maximum y coordinate (top border)
crs	character. PROJ.4 type description of a Coordinate Reference System (map projection). If this argument is missing, and the x coordinates are within -360 .. 360 and the y coordinates are within -90 .. 90, "+proj=longlat +datum=WGS84" is used
time	logical. If TRUE the time stamps are kept
props	logical. If TRUE the properties (categories and color-table) are kept
extent	object of class SpatExtent. If present, the arguments xmin, xmax, ymin and ymax are ignored
resolution	numeric vector of length 1 or 2 to set the resolution (see res). If this argument is used, arguments ncol and nrow are ignored
vals	numeric. An optional vector with cell values (if fewer values are provided, these are recycled to reach the number of cells)
names	character. An optional vector with layer names (must match the number of layers)
type	character. If the value is not "xyz", the raster has the same number of rows and columns as the matrix. If the value is "xyz", the matrix must have at least two columns, the first with x (or longitude) and the second with y (or latitude) coordinates that represent the centers of raster cells. The additional columns are the values associated with the raster cells.
digits	integer to set the precision for detecting whether points are on a regular grid (a low number of digits is a low precision). Only used when type="xyz"
...	additional arguments, in some cases passed on to the <code>rast,missing-method</code>

Details

The files are opened and read via GDAL. GDAL guesses the file format from the name, and/or else tries reading it with different "drivers" until it succeeds. In very few cases this may cause a file to be opened with wrong driver, and some information may be lost (for example because of opening a netCDF file with the HDF5 driver. You can avoid that by prepending the driver name to the filename like this: `rast('NETCDF:"filename.ncdf"')`

Value

SpatRaster

Examples

```
# Create a SpatRaster from scratch
x <- rast(nrows=108, ncols=21, xmin=0, xmax=10)

# Create a SpatRaster from a file
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)

s <- rast(system.file("ex/logo.tif", package="terra"))

# Create a skeleton with no associated cell values
rast(s)
```

rasterize

*Rasterize vector data***Description**

Transfer vector data to a raster

Usage

```
## S4 method for signature 'SpatVector,SpatRaster'
rasterize(x, y, field="", fun, ..., background=NA, touches=FALSE,
update=FALSE, sum=FALSE, cover=FALSE, filename="", overwrite=FALSE, wopt=list())
```

Arguments

x	SpatVector
y	SpatRaster
field	character or numeric. If field is a character, it should a variable name in x. If field is numeric it typically is a single number or a vector of length nrow(x). The values are recycled to nrow(x)
fun	function, summarizing function that returns a single number; for when there are multiple points in one cell. For example mean, length (to get a count), min or max. Only used if x consists of points
...	additional arguments passed to fun if x has point geometries
background	numeric. Value to put in the cells that are not covered by any of the features of x. Default is NA
touches	logical. If TRUE, all cells touched by lines or polygons are affected, not just those on the line render path, or whose center point is within the polygon. If touches=TRUE, add cannot be TRUE

update	logical. If TRUE, the values of the input SpatRaster are updated
sum	logical. If TRUE, the values of overlapping geometries are summed instead of replaced; and background is set to zero. Only used if x does not consists of points
cover	logical. If TRUE and the geometry of x is polygons, the fraction of a cell that is covered by the polygons is returned. This is estimated by determining presence/absence of the polygon in at least 100 sub-cells (more of there are very few cells)
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with additional arguments for writing files as in writeRaster

Value

SpatRaster

Note

To update existing raster data use the output of [rasterize](#) as second argument in [cover](#)

See Also

[mask](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
r <- rast(v, ncols=75, nrows=100)
#x <- rasterize(v, r, "NAME_2")

#plot(x)
#lines(v)
```

read and write

Read from, or write to, file

Description

Methods to read from or write chunks of values to or from a file. These are low level methods for programmers. Use [writeRaster](#) if you want to save an entire SpatRaster to file in one step. It is much easier to use.

To write chunks, begin by opening a file with [writeStart](#), then write values to it in chunks. When writing is done close the file with [writeStop](#).

Usage

```
## S4 method for signature 'SpatRaster'
readStart(x)

## S4 method for signature 'SpatRaster'
readStop(x)

## S4 method for signature 'SpatRaster'
readValues(x, row=1, nrows=nrow(x), col=1, ncols=ncol(x), mat=FALSE, dataframe=FALSE)

## S4 method for signature 'SpatRaster,character'
writeStart(x, filename="", overwrite=FALSE, n=4, ...)

## S4 method for signature 'SpatRaster'
writeStop(x)

## S4 method for signature 'SpatRaster,vector'
writeValues(x, v, start, nrows)
```

Arguments

x	SpatRaster
filename	character. Output filename
v	vector with cell values to be written
start	integer. Row number (counting starts at 1) from where to start writing v
row	positive integer. Row number to start from, should be between 1 and nrow(x)
nrows	positive integer. How many rows?
col	positive integer. Column number to start from, should be between 1 and ncol(x)
ncols	positive integer. How many columns? Default is the number of columns left after the start column
mat	logical. If TRUE, values are returned as a numeric matrix instead of as a vector, except when dataframe is TRUE. If any of the layers of x is a factor, the level index is returned, not the label. Use dataframe=TRUE to get the labels
dataframe	logical. If TRUE, values are returned as a data.frame instead of as a vector (also if matrix is TRUE)
overwrite	logical. If TRUE, filename is overwritten
n	positive integer indicating how many copies the data may be in memory at any point in time. This is used to determine how many blocks (large) datasets need to be read
...	additional arguments for writing files as in writeRaster

Value

readValues returns a vector, matrix, or data.frame

writeStart returns a list that can be used for processing the file in chunks.

The other methods invisibly return a logical value indicating whether they were succesful or not. Their purpose is the side-effect of opening or closing files.

rectify	<i>rectify a SpatRaster</i>
---------	-----------------------------

Description

Rectify a rotated SpatRaster into a non-rotated object

Usage

```
## S4 method for signature 'SpatRaster'
rectify(x, method="bilinear", aoI=NULL, snap=TRUE,
        filename="", ...)
```

Arguments

x	SpatRaster to be rectified
method	character. Method used to for resampling. See resample
aoI	SpatExtent or SpatRaster to crop x to a smaller area of interest; Using a SpatRaster allowing to set the exact output extent and output resolution
snap	logical. If TRUE, the origin and resolution of the output are the same as would the case when aoI = NULL. Only relevant if aoI is a SpatExtent
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

relate	<i>relate</i>
--------	---------------

Description

Get a matrix indicating the presence or absence of spatial relationships between geometries.

Usage

```
## S4 method for signature 'SpatVector,SpatVector'
relate(x, y, relation)

## S4 method for signature 'SpatVector,missing'
relate(x, y, relation, pairs=FALSE, symmetrical=FALSE)
```


Arguments

x	SpatVector or any object for which vect returns a SpatVector or else for which ext returns a SpatExtent
y	missing or as for x
relation	character. One of "intersects", "touches", "crosses", "overlaps", "within", "contains", "covers", "coveredby", "disjoint". Or a "DE-9IM" string such as "FF*FF*****". See wikipedia or geotools doc
pairs	logical. If TRUE a "from", "to" matrix is returned for the cases where the requested relation is TRUE
symmetrical	logical. If TRUE and pairs=TRUE, the relation between a pair is only included once. For example, the relation between geometry 1 and 3 is included, but the relation between 3 and 1 is not. Note that whole some relationships are symmetrical (e.g. "touches", other are not (e.g. "within"))

Value

matrix

See Also

[adjacent](#), [nearby](#), [intersect](#), [crop](#)

Examples

```
# polygons
p1 <- vect("POLYGON ((0 0, 8 0, 8 9, 0 9, 0 0))")
p2 <- vect("POLYGON ((5 6, 15 6, 15 15, 5 15, 5 6))")
p3 <- vect("POLYGON ((8 2, 9 2, 9 3, 8 3, 8 2))")
p4 <- vect("POLYGON ((2 6, 3 6, 3 8, 2 8, 2 6))")
p5 <- vect("POLYGON ((2 12, 3 12, 3 13, 2 13, 2 12))")
p6 <- vect("POLYGON ((10 4, 12 4, 12 7, 11 7, 11 6, 10 6, 10 4))")

p <- rbind(p1, p2, p3, p4, p5, p6)
plot(p, col=rainbow(6, alpha=.5))
lines(p, lwd=2)
text(p)

## relate SpatVectors
relate(p1, p2, "intersects")
relate(p1, p3, "touches")
relate(p1, p5, "disjoint")
relate(rbind(p1, p2), p4, "disjoint")

## relate geometries within SpatVectors
# which are completely separated?
relate(p, relation="disjoint")

# which touch (not overlap or within)?
relate(p, relation="touches")
```

```

# which overlap (not merely touch, and not within)?
relate(p, relation="overlaps")
# which are within (not merely overlap)?
relate(p, relation="within")

# do they touch or overlap or are within?
relate(p, relation="intersects")

all(relate(p, relation="intersects") ==
     (relate(p, relation="overlaps") |
      relate(p, relation="touches") |
      relate(p, relation="within")))

#for polygons, "coveredby" is "within"
relate(p, relation="coveredby")

# polygons, lines, and points

pp <- rbind(p1, p2)
L1 <- vect("LINESTRING(1 11, 4 6, 10 6)")
L2 <- vect("LINESTRING(8 14, 12 10)")
L3 <- vect("LINESTRING(1 8, 12 14)")
lns <- rbind(L1, L2, L3)
pts <- vect(cbind(c(7,10,10), c(3,5,6)))

plot(pp, col=rainbow(2, alpha=.5))
text(pp, paste0("POL", 1:2), halo=TRUE)
lines(pp, lwd=2)
lines(lns, col=rainbow(3), lwd=4)
text(lns, paste0("L", 1:3), halo=TRUE)
points(pts, cex=1.5)
text(pts, paste0("PT", 1:3), halo=TRUE, pos=4)

relate(lns, relation="crosses")
relate(lns, pp, relation="crosses")
relate(lns, pp, relation="touches")
relate(lns, pp, relation="intersects")

relate(lns, pp, relation="within")
# polygons can contain lines or points, not the other way around
relate(lns, pp, relation="contains")
relate(pp, lns, relation="contains")
# points and lines can be covered by polygons
relate(lns, pp, relation="coveredby")

relate(pts, pp, "within")
relate(pts, pp, "touches")
relate(pts, lns, "touches")

```

rep	<i>Replicate layers</i>
-----	-------------------------

Description

Replicate layers in a SpatRaster

Usage

```
## S4 method for signature 'SpatRaster'  
rep(x, ...)
```

Arguments

x	SpatRaster
...	arguments as in rep

Value

SpatRaster

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))  
x <- rep(s, 2)  
nlyr(x)  
names(x)  
x
```

replace	<i>Replace values of a SpatRaster</i>
---------	---------------------------------------

Description

Replace values of a SpatRaster. These are convenience functions for smaller objects only.

Value

SpatRaster

See Also

[values](#), [replace](#)

Examples

```
r <- rast(ncols=5, nrows=5, xmin=0, xmax=5, ymin=0, ymax=5)
r[] <- 1:25
r[,1] <- 5
r[,2] <- 10
r[r>10] <- NA
```

resample	<i>Transfer values of a SpatRaster to another one with a different geometry</i>
----------	---

Description

resample transfers values between SpatRaster objects that do not align (have a different origin and/or resolution). See [project](#) to change the coordinate reference system (crs).

If the origin and crs are the same, you should consider using these other functions instead: [aggregate](#), [disagg](#), [expand](#) or [crop](#).

Usage

```
## S4 method for signature 'SpatRaster,SpatRaster'
resample(x, y, method, filename="", ...)
```

Arguments

x	SpatRaster to be resampled
y	SpatRaster with the geometry that x should be resampled to
method	character. Method used for estimating the new cell values. One of: near: nearest neighbor. This method is fast, and it can be the preferred method if the cell values represent classes. It is not a good choice for continuous values. This is used by default if the first layer of x is categorical. bilinear: bilinear interpolation. This is the default if the first layer of x is numeric (not categorical). cubic: cubic interpolation. cubicspline: cubic spline interpolation. lanczos: Lanczos windowed sinc resampling.
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[aggregate](#), [disagg](#), [crop](#), [project](#),

Examples

```
r <- rast(nrows=3, ncols=3, xmin=0, xmax=10, ymin=0, ymax=10)
values(r) <- 1:ncell(r)
s <- rast(nrows=25, ncols=30, xmin=1, xmax=11, ymin=-1, ymax=11)
x <- resample(r, s, method="bilinear")

opar <- par(no.readonly =TRUE)
par(mfrow=c(1,2))
plot(r)
plot(x)
par(opar)
```

rescale

rescale

Description

Rescale a `SpatVector` or `SpatRaster`. This may be useful to make small [inset](#) maps or for georeferencing.

Usage

```
## S4 method for signature 'SpatRaster'
rescale(x, fx=0.5, fy=fx, x0, y0)

## S4 method for signature 'SpatVector'
rescale(x, fx=0.5, fy=fx, x0, y0)
```

Arguments

<code>x</code>	<code>SpatVector</code> or <code>SpatRaster</code>
<code>fx</code>	numeric > 0. The horizontal scaling factor
<code>fy</code>	numeric > 0. The vertical scaling factor
<code>x0</code>	numeric. x-coordinate of the center of rescaling. If missing, the center of the extent of <code>x</code> is used
<code>y0</code>	numeric. y-coordinate of the center of rescaling. If missing, the center of the extent of <code>x</code> is used

Value

Same as `x`

See Also

[t](#), [shift](#), [flip](#), [rotate](#), [inset](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
w <- rescale(v, 0.2)
plot(v)
lines(w, col="red")
```

 RGB

Declare RGB channels

Description

With RGB you can get or set the layers to be used as Red, Green and Blue when plotting a SpatRaster. Currently, the sole benefit of this is that `plot` will send the object to `plotRGB`

With `RGB2col` you can convert a three-layer RGB SpatRaster into a single-layer SpatRaster with a color-table.

Usage

```
## S4 method for signature 'SpatRaster'
RGB(x)

## S4 replacement method for signature 'SpatRaster'
RGB(x)<-value

## S4 method for signature 'SpatRaster'
RGB2col(x, value, stretch=NULL, grays=FALSE, filename="", overwrite=FALSE, ...)
```

Arguments

<code>x</code>	SpatRaster
<code>value</code>	vector of three (or four) positive integers indicating the layers that are red, green and blue (and optionally a fourth transparency layer). Or NULL to remove the RGB settings. With <code>RGB2col</code> , this argument can be missing if <code>RGB(x)</code> is not NULL
<code>stretch</code>	character. Option to stretch the values to increase contrast: "lin" (linear) or "hist" (histogram)
<code>grays</code>	logical. If TRUE, a gray-scale color-table is created
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If TRUE, filename is overwritten
<code>...</code>	additional arguments for writing files as in <code>writeRaster</code>

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
RGB(s) <- c(1,2,3)
plot(s)
RGB(s) <- NULL
```

rotate

Rotate a SpatRaster along longitude

Description

Rotate a SpatRaster that has longitude coordinates from 0 to 360, to standard coordinates between -180 and 180 degrees (or vice-versa). Longitude between 0 and 360 is frequently used in global climate models.

Usage

```
## S4 method for signature 'SpatRaster'
rotate(x, left=TRUE, filename="", ...)
```

Arguments

x	SpatRaster or SpatVector
left	logical. If TRUE, rotate to the left, else to the right
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[shift](#) and [spin](#)

Examples

```
x <- rast(nrows=9, ncols=18, nl=3, xmin=0, xmax=360)
v <- rep(as.vector(t(matrix(1:ncell(x), nrow=9, ncol=18))), 3)
values(x) <- v
z <- rotate(x)
```

`sapp`*Apply a terra function that takes only a single layer to all layers*

Description

Apply to all layers of a `SpatRaster` a function that only takes a single layer `SpatRaster` (these are rare). in most cases you can also use `lapply` or `sapply` for this.

Usage

```
## S4 method for signature 'SpatRaster'  
sapp(x, fun, ..., filename="", overwrite=FALSE, wopt=list())
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>fun</code>	a function that takes a <code>SpatRaster</code> argument and can be applied to each layer of <code>x</code>
<code>...</code>	additional arguments to be passed to <code>fun</code>
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If <code>TRUE</code> , <code>filename</code> is overwritten
<code>wopt</code>	list with named options for writing files as in writeRaster

Value

`SpatRaster`

See Also

[lapp](#), [app](#), [tapp](#), [lapply](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra")) + 1  
x <- sapp(s, terrain)
```

sbar	<i>scalebar</i>
------	-----------------

Description

Add a scalebar to a plot

Usage

```
sbar(d, xy=NULL, type="line", divs=2, below="",  
     lonlat=NULL, label, adj=c(0.5, -1), lwd=2, xpd=TRUE, ...)
```

Arguments

d	numeric. Distance covered by the scalebar. In the units of the coordinates of the plot, and in km for angular (longitude/latitude) data; see lonlat
xy	x and y coordinate to place the plot. Can be NULL. Use xy=click() to make this interactive
type	"line" or "bar"
divs	number of divisions for a bar: 2 or 4
below	character. Text to go below scalebar (e.g., "kilometers")
lonlat	logical or NULL. If logical, TRUE indicates if the plot is using longitude/latitude coordinates. If NULL this is guessed from the plot's coordinates
adj	adjustment for text placement
label	vector of three numbers to label the scale bar (beginning, midpoint, end)
lwd	line width for the "line" type scalebar
xpd	logical. If TRUE, the scalebar can be (partly) outside the plot area
...	graphical arguments to be passed to other methods

Value

none

See Also

[plot](#), [inset](#)

Examples

```
f <- system.file("ex/meuse.tif", package="terra")  
r <- rast(f)  
plot(r)  
sbar(1000)  
sbar(1000, xy=c(178500, 333500), type="bar", divs=4, cex=.8)
```

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
plot(r, type="interval")
sbar(20, c(6.2, 50.1), type="bar", cex=.8, divs=4)
sbar(15, c(6.3, 50), type="bar", below="km", label=c(0,7.5,15), cex=.8)
sbar(15, c(6.65, 49.9), cex=.8, label=c(0,"km",15))

sbar(15, c(6.65, 49.8), cex=.8, label="15 kilometer", lwd=5)

sbar(15, c(6.65, 49.7), divs=4, cex=.8, below="km")
```

scale

Scale values

Description

Center and/or scale raster data. For details see [link{scale}](#)

Usage

```
## S4 method for signature 'SpatRaster'
scale(x, center=TRUE, scale=TRUE)
```

Arguments

x	SpatRaster
center	logical or numeric. If TRUE, centering is done by subtracting the layer means (omitting NAs), and if FALSE, no centering is done. If center is a numeric vector (recycled to <code>nlyr(x)</code>), then each layer of x has the corresponding value from center subtracted from it.
scale	logical or numeric. If TRUE, scaling is done by dividing the (centered) layers of x by their standard deviations if center is TRUE, and the root mean square otherwise. If scale is FALSE, no scaling is done. If scale is a numeric vector (recycled to <code>nlyr(x)</code>), each layer of x is divided by the corresponding value. Scaling is done after centering.

Value

SpatRaster

See Also

[scale](#)

Examples

```

r <- rast(system.file("ex/logo.tif", package="terra"))
s <- scale(r)

## the equivalent, computed in steps
m <- global(r, "mean")
rr <- r - m[,1]
rms <- global(rr, "rms")
ss <- rr / rms[,1]

```

scatterplot

*Scatterplot of two SpatRaster layers***Description**

Scatterplot of the values of two SpatRaster layers

Usage

```

## S4 method for signature 'SpatRaster,SpatRaster'
plot(x, y, maxcell=100000, warn=TRUE, nc, nr,
     maxnl=16, gridded=FALSE, ncol=25, nrow=25, ...)

```

Arguments

x	SpatRaster
y	SpatRaster
maxcell	positive integer. Maximum number of cells to use for the plot
nc	positive integer. Optional. The number of columns to divide the plotting device in (when plotting multiple layers)
nr	positive integer. Optional. The number of rows to divide the plotting device in (when plotting multiple layers)
maxnl	positive integer. Maximum number of layers to plot (for multi-layer objects)
gridded	logical. If TRUE the scatterplot is gridded (counts by cells)
warn	boolean. Show a warning if a sample of the pixels is used (for scatterplot only)
ncol	positive integer. Number of columns for gridding
nrow	positive integer. Number of rows for gridding
...	additional graphical arguments

Examples

```

s <- rast(system.file("ex/logo.tif", package="terra"))
plot(s[[1]], s[[2]])
plot(s, sqrt(s[[3:1]]))

```

`sds`*Create a SpatRasterDataset*

Description

Methods to create a `SpatRasterDataset`. This is an object to hold "sub-datasets", each a `SpatRaster` that in most cases will have multiple layers.

See [describe](#) for getting information about the sub-datasets present in a file.

Usage

```
## S4 method for signature 'missing'
sds(x)

## S4 method for signature 'character'
sds(x, ids=0)

## S4 method for signature 'SpatRaster'
sds(x, ...)

## S4 method for signature 'list'
sds(x)
```

Arguments

<code>x</code>	character (filename), or <code>SpatRaster</code> , or list of <code>SpatRaster</code> objects, or missing. If multiple filenames are provided, it is attempted to make <code>SpatRasters</code> from these, and combine them into a <code>SpatRasterDataset</code>
<code>ids</code>	optional. vector of integer subdataset ids. Ignored if the first value is not a positive integer
<code>...</code>	additional arguments. Can be other <code>SpatRaster</code> objects if <code>x</code> is a <code>SpatRaster</code>

Value

`SpatRasterDataset`

See Also

[describe](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
x <- sds(s, s/2)
names(x) <- c("first", "second")
x
length(x)
```

```
# extract the second SpatRaster
x[2]
```

segregate	<i>segregate</i>
-----------	------------------

Description

Create a `SpatRaster` with a layer for each class (value, or subset of the values) in the input `SpatRaster`. For example, if the input has vegetation types, this function will create a layer (presence/absence; dummy variable) for each of these classes. Classes and cell values are always truncated to integers.

This is called "one-hot encoding" or "dummy encoding" (for a dummy encoding scheme you can remove (any) one of the output layers as it is redundant).

Usage

```
## S4 method for signature 'SpatRaster'
segregate(x, classes=NULL, keep=FALSE, other=0, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>classes</code>	numeric. The values (classes) for which layers should be made. If <code>NULL</code> all classes are used
<code>keep</code>	logical. If <code>TRUE</code> , cells that are of the class represented by a layer get that value, rather than a value of 1
<code>other</code>	numeric. Value to assign to cells that are not of the class represented by a layer
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

Examples

```
r <- rast(nrows=5, ncols=5)
values(r) <- rep(c(1:4, NA), each=5)
b <- segregate(r)
bb <- segregate(r, keep=TRUE, other=NA)
```

sel	<i>Spatial selection</i>
-----	--------------------------

Description

Geometrically subset `SpatRaster` or `SpatVector` (to be done) by drawing on a plot (map).

Usage

```
## S4 method for signature 'SpatRaster'  
sel(x, ...)  
  
## S4 method for signature 'SpatVector'  
sel(x, use="rec", draw=TRUE, col="cyan", ...)
```

Arguments

x	<code>SpatRaster</code> or <code>SpatVector</code>
use	character indicating what to draw. One of "rec" (rectangle) or "pol" (polygon)
draw	logical. If TRUE the selection is drawn on the map
col	color to be used for drawing if draw=TRUE
...	additional graphics arguments for drawing

Value

`SpatRaster` or `SpatVector`

See Also

[crop](#) and [intersect](#) to make an intersection and [click](#) and [text](#) to see cell values or geometry attributes

Examples

```
## Not run:  
# select a subset of a SpatRaster  
r <- rast(nrows=10, ncols=10)  
values(r) <- 1:ncell(r)  
plot(r)  
s <- sel(r) # now click on the map twice  
  
# plot the selection on a new canvas:  
x11()  
plot(s)  
  
# vector  
f <- system.file("ex/lux.shp", package="terra")
```

```
v <- vect(f)
plot(v)
x <- sel(v) # now click on the map twice
x

## End(Not run)
```

selectRange	<i>Select the values of a range of layers, as specified by cell values in another SpatRaster</i>
-------------	--

Description

Use a single layer SpatRaster to select cell values from different layers in a multi-layer SpatRaster. The values of the SpatRaster to select layers (y) should be whole numbers between 1 and nlyr(x) (values outside this range are ignored).

See [rapp](#) for applying af function to a range of variable size.

See [extract](#) for extraction of values by cell, point, or otherwise.

Usage

```
## S4 method for signature 'SpatRaster'
selectRange(x, y, z=1, repint=0, filename="", ...)
```

Arguments

x	SpatRaster
y	SpatRaster. Cell values must be positive integers. They indicate the first layer to select for each cell
z	positive integer. The number of layers to select
repint	integer > 1 and < nlyr(x) allowing for repeated selection at a fixed interval. For example, if x has 36 layers, and the value of a cell in y=2 and repint = 12, the values for layers 2, 14 and 26 are returned
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[rapp](#), [tapp](#), [extract](#)

Examples

```

r <- rast(ncols=10, nrows=10)
values(r) <- 1
s <- c(r, r+2, r+5)
s <- c(s, s)
set.seed(1)
values(r) <- sample(3, ncell(r), replace=TRUE)
x <- selectRange(s, r)

x <- selectRange(s, r, 3)

```

setValues

Set the values of raster cells or of geometry attributes

Description

Set cell values of a `SpatRaster` or the attributes of a `SpatVector`. For large `SpatRaster` objects use `init` instead to set values.

Usage

```

## S4 replacement method for signature 'SpatRaster,ANY'
values(x)<-value

## S4 method for signature 'SpatRaster,ANY'
setValues(x, values, time=TRUE, props=FALSE)

## S4 replacement method for signature 'SpatVector,ANY'
values(x)<-value

```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>value</code>	For <code>SpatRaster</code> : matrix or numeric, the length must match the total number of cells ($ncell(x) * nlyr(x)$), or be a single value. For <code>SpatVector</code> : data.frame, matrix, vector, or NULL
<code>values</code>	Same as for <code>value</code>
<code>time</code>	logical. If TRUE the time stamps are kept
<code>props</code>	logical. If TRUE the properties (categories and color-table) are kept

Value

The same object type as `x`

See Also

`values`, `init`

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
x <- setValues(r, 1:ncell(r))
x
values(x) <- runif(ncell(x))
x
head(x)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
values(v) <- data.frame(ID=1:12, name=letters[1:12])
head(v)
```

 shade

Hill shading

Description

Compute hill shade from slope and aspect layers (both in radians). Slope and aspect can be computed with function [terrain](#).

A hill shade layer is often used as a backdrop on top of which another, semi-transparent, layer is drawn.

Usage

```
shade(slope, aspect, angle=45, direction=0, normalize=FALSE, filename="", ...)
```

Arguments

slope	SpatRaster with slope values (in radians)
aspect	SpatRaster with aspect values (in radians)
angle	The the elevation angle of the light source (sun), in degrees
direction	The direction (azimuth) angle of the light source (sun), in degrees
normalize	Logical. If TRUE, values below zero are set to zero and the results are multiplied with 255
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

References

Horn, B.K.P., 1981. Hill shading and the reflectance map. *Proceedings of the IEEE* 69(1):14-47

See Also

[terrain](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
alt <- disagg(r, 10, method="bilinear")
slope <- terrain(alt, "slope", unit="radians")
aspect <- terrain(alt, "aspect", unit="radians")
hill <- shade(slope, aspect, 40, 270)
plot(hill, col=grey(0:100/100), legend=FALSE, mar=c(2,2,1,4))
plot(alt, col=rainbow(25, alpha=0.35), add=TRUE)
```

 shift
*Shift***Description**

Shift a `SpatRaster`, `SpatVector` or `SpatExtent` to another location.

Usage

```
## S4 method for signature 'SpatRaster'
shift(x, dx=0, dy=0, filename="", ...)

## S4 method for signature 'SpatVector'
shift(x, dx=0, dy=0)

## S4 method for signature 'SpatExtent'
shift(x, dx=0, dy=0)
```

Arguments

<code>x</code>	<code>SpatRaster</code> , <code>SpatVector</code> or <code>SpatExtent</code>
<code>dx</code>	numeric. The shift in horizontal direction
<code>dy</code>	numeric. The shift in vertical direction
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

Same as `x`

See Also

[flip](#), [rotate](#)

Examples

```
r <- rast(xmin=0, xmax=1, ymin=0, ymax=1)
r <- shift(r, dx=1, dy=-1)

e <- ext(r)
shift(e, 5, 5)
```

sources *Data sources of a SpatRaster*

Description

Get the data sources of a SpatRaster and the number of layers by source. Sources are either files (or similar resources) or "", meaning that they are in memory. You can use `hasValues` to check if in-memory layers actually have cell values.

Usage

```
## S4 method for signature 'SpatRaster'
sources(x)

## S4 method for signature 'SpatRaster'
hasValues(x)

## S4 method for signature 'SpatRaster'
inMemory(x, bylayer=FALSE)
```

Arguments

x	SpatRaster
bylayer	logical. If TRUE a value is returned for each layer instead of for each source

Value

`sources` returns a data.frame with the source names (if any) and the number of layers by source

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
s <- rast(r)
values(s) <- 1:ncell(s)
rs <- c(r,r,s,r)
sources(rs)
hasValues(r)
x <- rast()
hasValues(x)
```

SpatExtent-class *Class "SpatExtent"*

Description

Objects of class `SpatExtent` are used to define the spatial extent (extremes) of objects of the `SpatRaster` class.

Objects from the Class

You can use the `ext` function to create `SpatExtent` objects, or to extract them from `SpatRaster` objects.

Slots

`ptr`: pointer to the C++ class

Methods

`show` display values of a `SpatExtent` object

Examples

```
e <- ext(-180, 180, -90, 90)
e
```

Spatial interpolation *Interpolate*

Description

Make a `SpatRaster` with interpolated values using a fitted model object of classes such as "gstat" (gstat package) or "Krige" (fields package), or any other model that has location (e.g., "x" and "y", or "longitude" and "latitude") as predictors (independent variables). If x and y are the only predictors, it is most efficient if you provide an empty (no associated data in memory or on file) `SpatRaster` for which you want predictions. If there are more spatial predictor variables provide these as a `SpatRaster` in the first argument of the function. If you do not have x and y locations as implicit predictors in your model you should use `predict` instead.

Usage

```
## S4 method for signature 'SpatRaster'
interpolate(object, model, fun=predict, ..., xyNames=c("x", "y"),
            factors=NULL, const=NULL, index = NULL, na.rm=FALSE,
            filename="", overwrite=FALSE, wopt=list())
```

Arguments

object	SpatRaster
model	model object
fun	function. Default value is "predict", but can be replaced with e.g. "predict.se" (depending on the class of model), or a custom function (see examples)
...	additional arguments passed to fun
xyNames	character. variable names that the model uses for the spatial coordinates. E.g., c("longitude", "latitude")
factors	list with levels for factor variables. The list elements should be named with names that correspond to names in object such that they can be matched. This argument may be omitted for some models from which the levels can be extracted from the model object
const	data.frame. Can be used to add a constant for which there is no SpatRaster for model predictions. This is particularly useful if the constant is a character-like factor value
index	positive integer or NULL. Allows for selecting of the variable returned if the model returns multiple variables
na.rm	logical. If TRUE, cells with NA values in the predictors are removed from the computation. This option prevents errors with models that cannot handle NA values. In most other cases this will not affect the output. An exception is when predicting with a model that returns predicted values even if some (or all!) variables are NA
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
wopt	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also

[predict](#)

Examples

```
r <- rast(system.file("ex/elev.tif", package="terra"))
ra <- aggregate(r, 10)
xy <- data.frame(xyFromCell(ra, 1:ncell(ra)))
v <- values(ra)
i <- !is.na(v)
xy <- xy[i,]
v <- v[i]

## Not run:
```

```

library(fields)
tps <- Tps(xy, v)
p <- rast(r)

# use model to predict values at all locations
p <- interpolate(p, tps)
p <- mask(p, r)
plot(p)

### change "fun" from predict to fields::predictSE to get the TPS standard error
## need to use "rast(p)" to remove the values
se <- interpolate(rast(p), tps, fun=predictSE)
se <- mask(se, r)
plot(se)

### another predictor variable, "e"
e <- (init(r, "x") * init(r, "y")) / 100000000
names(e) <- "e"

z <- as.matrix(extract(e, xy)[,-1])

## add as another independent variable
xyz <- cbind(xy, z)
tps2 <- Tps(xyz, v)
p2 <- interpolate(e, tps2, xyOnly=FALSE)

## as a linear covariate
tps3 <- Tps(xy, v, Z=z)

## Z is a separate argument in Krig.predict, so we need a new function
## Internally (in interpolate) a matrix is formed of x, y, and elev (Z)

pfun <- function(model, x, ...) {
  predict(model, x[,1:2], Z=x[,3], ...)
}
p3 <- interpolate(e, tps3, fun=pfun)

#### gstat examples
library(gstat)
library(sp)
data(meuse)

### inverse distance weighted (IDW)
r <- rast(system.file("ex/meuse.tif", package="terra"))
mg <- gstat(id = "zinc", formula = zinc~1, locations = ~x+y, data=meuse,
           nmax=7, set=list(idp = .5))
z <- interpolate(r, mg, debug.level=0, index=1)
z <- mask(z, r)

## with a model built with an `sf` object you need to provide custom function

library(sf)

```

```

sfmeuse <- st_as_sf(meuse, coords = c("x", "y"), crs=crs(r))
mgstf <- gstat(id = "zinc", formula = zinc~1, data=sfmeuse, nmax=7, set=list(idp = .5))

interpolate_gstat <- function(model, x, crs, ...) {
  v <- st_as_sf(x, coords=c("x", "y"), crs=crs)
  p <- predict(model, v, ...)
  as.data.frame(p)[1:2]
}

zsf <- interpolate(r, mgstf, debug.level=0, fun=interpolate_gstat, crs=crs(r), index=1)
zsf <- mask(zsf, r)

### kriging

### ordinary kriging
v <- variogram(log(zinc)~1, ~x+y, data=meuse)
mv <- fit.variogram(v, vgm(1, "Sph", 300, 1))
gOK <- gstat(NULL, "log.zinc", log(zinc)~1, meuse, locations=~x+y, model=mv)
OK <- interpolate(r, gOK, debug.level=0)

## universal kriging
vu <- variogram(log(zinc)~elev, ~x+y, data=meuse)
mu <- fit.variogram(vu, vgm(1, "Sph", 300, 1))
gUK <- gstat(NULL, "log.zinc", log(zinc)~elev, meuse, locations=~x+y, model=mu)
names(r) <- "elev"
UK <- interpolate(r, gUK, debug.level=0)

## co-kriging
gCoK <- gstat(NULL, 'log.zinc', log(zinc)~1, meuse, locations=~x+y)
gCoK <- gstat(gCoK, 'elev', elev~1, meuse, locations=~x+y)
gCoK <- gstat(gCoK, 'cadmium', cadmium~1, meuse, locations=~x+y)
gCoK <- gstat(gCoK, 'copper', copper~1, meuse, locations=~x+y)
coV <- variogram(gCoK)
plot(coV, type='b', main='Co-variogram')
coV.fit <- fit.lmc(coV, gCoK, vgm(model='Sph', range=1000))
coV.fit
plot(coV, coV.fit, main='Fitted Co-variogram')
coK <- interpolate(r, coV.fit, debug.level=0)
plot(coK)

## End(Not run)

```

SpatRaster-class

SpatRaster class

Description

A *SpatRaster* represents a rectangular part of the world that is sub-divided into rectangular cells of equal area (in terms of the units of the coordinate reference system). For each cell can have multiple values ("layers").

An object of the SpatRaster class can point to one or more files on disk that hold the cell values, and/or it can hold these values in memory. These objects can be created with the `rast` method.

The underlying C++ class "Rcpp_SpatRaster" is not intended for end-users. It is for internal use within this package only.

Examples

```
rast()
```

```
spatSample
```

```
Take a regular sample
```

Description

Take a spatial sample from a SpatRaster, SpatVector or SpatExtent. Sampling a SpatVector or SpatExtent always returns a SpatVector of points.

With a SpatRaster, you can get cell values, cell numbers (`cells=TRUE`), coordinates (`xy=TRUE`) or (when `type="regular"` and `as.raster=TRUE`) get a new SpatRaster with the same extent, but fewer cells.

In order to assure regularity when requesting a regular sample, the number of cells or points returned may not be exactly the same as the size requested.

Usage

```
## S4 method for signature 'SpatRaster'
spatSample(x, size, method="random", replace=FALSE, na.rm=FALSE,
as.raster=FALSE, as.df=TRUE, as.points=FALSE, values=TRUE,
cells=FALSE, xy=FALSE, ext=NULL, warn=TRUE)
```

```
## S4 method for signature 'SpatVector'
spatSample(x, size, method="random", strata=NULL, chess="")
```

```
## S4 method for signature 'SpatExtent'
spatSample(x, size, method="random", lonlat, as.points=FALSE)
```

Arguments

<code>x</code>	SpatRaster
<code>size</code>	numeric. The sample size. If <code>x</code> is a SpatVector, you can also provide a vector of the same length as <code>x</code> in which case sampling is done separately for each geometry. If <code>x</code> is a SpatRaster, and you are using <code>method="regular"</code> you can specify the size as two numbers (number of rows and columns)
<code>method</code>	character. Should be "regular" or "random"
<code>replace</code>	logical. If TRUE, sampling is with replacement (if <code>method="random"</code>)

na.rm	logical. If TRUE, codeNAs are removed. Only used with random sampling of cell values. That is with method="random", as.raster=FALSE, cells=FALSE
as.raster	logical. If TRUE, a SpatRaster is returned
as.df	logical. If TRUE, a data.frame is returned instead of a matrix
as.points	logical. If TRUE, a SpatVector of points is returned
values	logical. If TRUE cell values are returned
cells	logical. If TRUE, cell numbers are returned
xy	logical. If TRUE, cell coordinates are returned
ext	SpatExtent or NULL to restrict sampling to a subset of the area of x
warn	logical. Give a warning if the sample size returned is smaller than requested
strata	if not NULL, stratified random sampling is done, taking size samples from each stratum. If x has polygon geometry, strata must be a field name (or index) in x. If x has point geometry, strata can be a SpatVector of polygons or a SpatRaster
chess	character. One of "", "white", or "black". For stratified sampling if strata is a SpatRaster. If not "", samples are only taken from alternate cells, organized like the "white" or "black" fields on a chessboard
lonlat	logical. If TRUE, sampling of a SpatExtent is weighted by cos(latitude). For SpatRaster and SpatVector this done based on the <code>crs</code> , but it is ignored if as.raster=TRUE

Value

numeric or SpatRaster

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
s <- spatSample(r, 10, as.raster=TRUE)
spatSample(r, 10)
spatSample(r, 10, "random")

## if you require cell numbers and/or coordinates
size <- 6
# random cells
cells <- spatSample(r, 6, "random", cells=TRUE, values=FALSE)
cells <- as.vector(cells)

v <- r[cells]
xy <- xyFromCell(r, cells)
cbind(xy, v)

# regular
cells <- spatSample(r, 6, "regular", cells=TRUE, values=FALSE)
cells <- as.vector(cells)
v <- r[cells]
xy <- xyFromCell(r, cells)
```

```

cbind(xy, v)

## SpatExtent
e <- ext(r)
spatSample(e, 10, "random", lonlat=TRUE)

## SpatVector
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
#sample geometries
i <- sample(nrow(v), 5)
vv <- v[i,]

```

SpatVector-class	<i>Class "SpatVector"</i>
------------------	---------------------------

Description

Objects of class SpatVector.

Objects from the Class

You can use the [vect](#) method to create SpatVector objects.

Slots

ptr: pointer to the C++ class

Methods

show display values of a SpatVector

spin	<i>spin a SpatVector</i>
------	--------------------------

Description

Spin (rotate) the geometry of a SpatVector.

Usage

```

## S4 method for signature 'SpatVector'
spin(x, angle, x0, y0)

```

Arguments

x	SpatVector
angle	numeric. Angle of rotation in degrees
x0	numeric. x-coordinate of the center of rotation. If missing, the center of the extent of x is used
y0	numeric. y-coordinate of the center of rotation. If missing, the center of the extent of x is used

Value

SpatVector

See Also

[rescale](#), [t](#), [shift](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
w <- spin(v, 180)
plot(v)
lines(w, col="red")

# lower-right corner as center
e <- as.vector(ext(v))
x <- spin(v, 45, e[1], e[3])
```

split

Split

Description

Split a SpatVector

Usage

```
## S4 method for signature 'SpatRaster'
split(x, f)

## S4 method for signature 'SpatVector'
split(x, f)
```

Arguments

x	SpatRaster or SpatVector
f	If x is a SpatVector: a field (variable) name or a vector of the same length as x. If x is a SpatRaster: a vector of the length nlyr(x)

Value

Same as x

Examples

```
v <- vect(system.file("ex/lux.shp", package="terra"))
x <- split(v, "NAME_1")

s <- rast(system.file("ex/logo.tif", package="terra"))
y <- split(s, c(1,2,1))
sds(y)
```

src

Create a SpatRasterCollection

Description

Methods to create a SpatRasterCollection. This is an object to hold a collection (list) of SpatRaster objects. There are no restrictions on the similarity of the SpatRaster geometry.

They can be used to combine several SpatRasters to be used with [merge](#) or [mosaic](#)

Usage

```
## S4 method for signature 'SpatRaster'
src(x, ...)
```

```
## S4 method for signature 'list'
src(x)
```

```
## S4 method for signature 'missing'
src(x)
```

Arguments

x	SpatRaster, list with SpatRaster objects, or missing
...	additional SpatRaster objects

Value

SpatRasterCollection

See Also

[sds](#)

Examples

```
x <- rast(xmin=-110, xmax=-50, ymin=40, ymax=70, ncols=60, nrows=30)
y <- rast(xmin=-80, xmax=-20, ymax=60, ymin=30)
res(y) <- res(x)
values(x) <- 1:ncell(x)
values(y) <- 1:ncell(y)

z <- src(x, y)
z
```

stretch

*Stretch***Description**

Linear stretch of values in a `SpatRaster` object. Provide the desired output range (`minv` and `maxv`) and the lower and upper bounds in the original data, either as quantiles (`minq` and `maxq`, or as cell values (`smin` and `smax`). If `smin` and `smax` are both not `NA`, `minq` and `maxq` are ignored.

Usage

```
## S4 method for signature 'SpatRaster'
stretch(x, minv=0, maxv=255, minq=0, maxq=1, smin=NA, smax=NA, filename="", ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>minv</code>	numeric ≥ 0 and smaller than <code>maxv</code> . lower bound of stretched value
<code>maxv</code>	numeric ≤ 255 and larger than <code>minv</code> . upper bound of stretched value
<code>minq</code>	numeric ≥ 0 and smaller than <code>maxq</code> . lower quantile bound of original value. Ignored if <code>smin</code> is supplied
<code>maxq</code>	numeric ≤ 1 and larger than <code>minq</code> . upper quantile bound of original value. Ignored if <code>smax</code> is supplied
<code>smin</code>	numeric $< smax$. user supplied lower value for the layers, to be used instead of a quantile computed by the function itself
<code>smax</code>	numeric $> smin$. user supplied upper value for the layers, to be used instead of a quantile computed by the function itself
<code>filename</code>	character. Output filename
<code>...</code>	additional arguments for writing files as in writeRaster

Value

`SpatRaster`

Examples

```
r <- rast(nc=10, nr=10)
values(r) <- rep(1:25, 4)
rs <- stretch(r)
s <- c(r, r*2)
sr <- stretch(s)
```

subset

*Subset of a SpatRaster***Description**

Select a subset of layers from a SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
subset(x, subset, filename="", overwrite=FALSE, ...)
```

Arguments

x	SpatRaster
subset	integer or character. Should indicate the layers (represented as integer or by their names)
filename	character. Output filename
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))
subset(s, 2:3)
subset(s, c(3,2,3,1))
#equivalent to
s[[ c(3,2,3,1) ]]

s[[c("red", "green")]]
s$red

# expression based (partial) matching of names with single brackets
s["re"]
s["^re"]
```

```
# not with double brackets
# s[["re"]]
```

subset-vector	<i>Subset of a SpatVector</i>
---------------	-------------------------------

Description

Select a subset of variables or records from a SpatVector.

Usage

```
## S4 method for signature 'SpatVector'
subset(x, subset, drop=FALSE)
```

Arguments

x	SpatVector
subset	logical expression indicating elements or rows to keep: missing values are taken as false
drop	logical. If TRUE, the geometries will be dropped, and a data.frame is returned

Value

SpatVector or, if drop=TRUE, a data.frame.

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v[2:3,]
v[,2:3]
subset(v, v$NAME_1 == "Diekirch")
```

subst	<i>replace cell values</i>
-------	----------------------------

Description

Substitute(replace) cell values of a SpatRaster with a new value. See [classify](#) for more complex/flexible replacement.

Usage

```
## S4 method for signature 'SpatRaster'
subst(x, from, to, filename="", ...)
```

Arguments

<code>x</code>	SpatRaster
<code>from</code>	numeric value(s)
<code>to</code>	numeric value(s). Normally a vector of the same length as 'from'. If <code>x</code> has a single layer, it can also be a matrix of numeric value(s) where <code>nrow(x) == length(from)</code> . In that case the output has multiple layers, one for each column in <code>to</code>
<code>filename</code>	character. Output filename
<code>...</code>	Additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[classify](#)

Examples

```
r <- rast(ncols=5, nrows=5, xmin=0, xmax=1, ymin=0, ymax=1, crs="")
r <- init(r, 1:6)
x <- subst(r, 3, 7)
x <- subst(r, 2:3, NA)
x <- subst(x, NA, 10)
```

summarize

Summarize

Description

Compute summary statistics for cells, either across layers or between layers (parallel summary).

The following summary methods are available for SpatRaster: `any`, `all`, `max`, `min`, `mean`, `median`, `prod`, `range`, `stdev`, `sum`, `w`. See [modal](#) to compute the mode and [app](#) to compute summary statistics that are not included here.

Because generic functions are used, the method applied is chosen based on the first argument: "x". This means that if `r` is a SpatRaster, `mean(r, 5)` will work, but `mean(5, r)` will not work.

The mean method has an argument "trim" that is ignored.

If `pop=TRUE` `stdev` computes the population standard deviation, computed as:

```
f <-function(x) sqrt(sum((x-mean(x))^2) / length(x))
```

This is different than the sample standard deviation returned by `sd` (which uses `n-1` as denominator).

Usage

```
## S4 method for signature 'SpatRaster'  
min(x, ..., na.rm=FALSE)  
  
## S4 method for signature 'SpatRaster'  
max(x, ..., na.rm=FALSE)  
  
## S4 method for signature 'SpatRaster'  
range(x, ..., na.rm=FALSE)  
  
## S4 method for signature 'SpatRaster'  
mean(x, ..., trim=NA, na.rm=FALSE)  
  
## S4 method for signature 'SpatRaster'  
median(x, na.rm=FALSE)  
  
## S4 method for signature 'SpatRaster'  
stdev(x, ..., pop=TRUE, na.rm=FALSE)  
  
## S4 method for signature 'SpatRaster'  
which.min(x)  
  
## S4 method for signature 'SpatRaster'  
which.max(x)
```

Arguments

x	SpatRaster
...	additional SpatRaster objects or numeric values; and arguments filename, overwrite and wopt as for writeRaster
na.rm	logical. If TRUE, NA values are ignored. If FALSE, NA is returned if x has any NA values
trim	ignored
pop	logical. If TRUE, the population standard deviation is computed. Otherwise the sample standard deviation is computed

Value

SpatRaster

See Also

[app](#), [Math-methods](#), [modal](#), [which.lyr](#)

Examples

```
set.seed(0)  
r <- rast(nrows=10, ncols=10, nlyrs=3)
```

```

values(r) <- runif(ncell(r) * nlyr(r))

x <- mean(r)
# note how this returns one layer
x <- sum(c(r, r[[2]]), 5)

# and this returns three layers
y <- sum(r, r[[2]], 5)

max(r)
max(r, 0.5)

y <- stdev(r)
# not the same as
yy <- app(r, sd)

z <- stdev(r, r*2)

```

summary

summary

Description

Compute summary statistics (min, max, mean, and quartiles) for `SpatRaster` using base [summary](#) method. A sample is used for very large files.

For single or other statistics see [Summary-methods](#), [global](#), and [quantile](#)

Usage

```

## S4 method for signature 'SpatRaster'
summary(object, size=100000, warn=TRUE, ...)

## S4 method for signature 'SpatVector'
summary(object, ...)

```

Arguments

<code>object</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>size</code>	positive integer. Size of a regular sample used for large datasets (see spatSample)
<code>warn</code>	logical. If TRUE a warning is given if a sample is used
<code>...</code>	additional arguments passed on to the base summary method

Value

matrix with (an estimate of) the median, minimum and maximum values, the first and third quartiles, and the number of cells with NA values

See Also

[Summary-methods](#), [global](#), [quantile](#)

Examples

```
set.seed(0)
r <- rast(nrows=10, ncols=10, nlyrs=3)
values(r) <- runif(nlyr(r)*ncell(r))
summary(r)
```

 svc

Create a SpatVectorCollection

Description

Methods to create a SpatVectorCollection. This is an object to hold "sub-datasets", each a SpatVector, perhaps of different geometry type.

Usage

```
## S4 method for signature 'missing'
svc(x, ...)

## S4 method for signature 'SpatVector'
svc(x, ...)

## S4 method for signature 'list'
svc(x, ...)
```

Arguments

x SpatVector, or list of SpatVector objects, or missing
 ... additional arguments. Can be other SpatVector objects if x is a SpatVector

Value

SpatVectorCollection

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
x <- svc()
x <- svc(v, v[1:3,], as.lines(v[3:5,]), as.points(v))
length(x)
x

# extract
```

```
x[3]
# replace
x[2] <- as.lines(v[1,])
```

symdif

Symmetrical difference

Description

Symmetrical difference of polygons

Usage

```
## S4 method for signature 'SpatVector,SpatVector'
symdif(x, y)
```

Arguments

x	SpatVector
y	SpatVector

Value

SpatVector

See Also

[erase](#)

Examples

```
p <- vect(system.file("ex/lux.shp", package="terra"))
b <- as.polygons(ext(6, 6.4, 49.75, 50))
#sd <- symdif(p, b)
#plot(sd, col=rainbow(12))
```

tapp

Apply a function to subsets of layers of a SpatRaster

Description

Apply a function to subsets of layers of a SpatRaster (similar to [tapply](#) and [aggregate](#)). The layers are combined based on the `index`.

The function used should return a single value, and the number of layers in the output SpatRaster equals the number of unique values in `index`.

For example, if you have a SpatRaster with 6 layers, you can use `index=c(1,1,1,2,2,2)` and `fun=sum`. This will return a SpatRaster with two layers. The first layer is the sum of the first three layers in the input SpatRaster, and the second layer is the sum of the last three layers in the input SpatRaster. Indices are recycled such that `index=c(1,2)` would also return a SpatRaster with two layers (one based on the odd layers (1,3,5), the other based on the even layers (2,4,6)).

See [app](#) or [Summary-methods](#) if you want to use a more efficient function that returns multiple layers based on **all** layers in the SpatRaster object.

Usage

```
## S4 method for signature 'SpatRaster'
tapp(x, index, fun, ..., filename="", overwrite=FALSE, wopt=list())
```

Arguments

<code>x</code>	SpatRaster
<code>index</code>	factor or numeric (integer). Vector of length <code>nlyr(x)</code> (shorter vectors are recycled) grouping the input layers
<code>fun</code>	function to be applied
<code>...</code>	additional arguments passed to <code>fun</code>
<code>filename</code>	character. Output filename
<code>overwrite</code>	logical. If TRUE, <code>filename</code> is overwritten
<code>wopt</code>	list with named options for writing files as in writeRaster

Value

SpatRaster

See Also

[app](#), [Summary-methods](#)

Examples

```

r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
s <- c(r, r, r, r, r, r)
s <- s * 1:6
b1 <- tapp(s, index=c(1,1,1,2,2,2), fun=sum)
b1
b2 <- tapp(s, c(1,2,3,1,2,3), fun=sum)
b2

```

terrain

terrain characteristic

Description

Compute terrain characteristic from elevation data. The elevation values should be the same as the map units (typically meter) for projected (planar) raster data. They should be in meter when the coordinate reference system (CRS) is longitude/latitude.

Usage

```

## S4 method for signature 'SpatRaster'
terrain(x, v="slope", neighbors=8, unit="degrees", filename="", ...)

```

Arguments

x	SpatRaster, single layer with elevation values. Values should have the same unit as the map units, or in meters when the crs is longitude/latitude
v	character. One or more of these options: slope, aspect, TPI, TRI, roughness, flowdir (see Details)
unit	character. "degrees" or "radians" for the output of "slope" and "aspect"
neighbors	integer. Indicating how many neighboring cells to use to compute slope or aspect with. Either 8 (queen case) or 4 (rook case)
filename	character. Output filename
...	list. Options for writing files as in writeRaster

Details

When neighbors=4, slope and aspect are computed according to Fleming and Hoffer (1979) and Ritter (1987). When neighbors=8, slope and aspect are computed according to Horn (1981). The Horn algorithm may be best for rough surfaces, and the Fleming and Hoffer algorithm may be better for smoother surfaces (Jones, 1997; Burrough and McDonnell, 1998).

If slope = 0, aspect is set to $0.5 \cdot \pi$ radians (or 90 degrees if unit="degrees"). When computing slope or aspect, the coordinate reference system of x must be known for the algorithm to differentiate between planar and longitude/latitude data.

terrain is not vectorized over "neighbors" or "unit" – only the first value is used.

flowdir returns the "flow direction" (of water), that is the direction of the greatest drop in elevation (or the smallest rise if all neighbors are higher). They are encoded as powers of 2 (0 to 7). The cell to the right of the focal cell is 1, the one below that is 2, and so on:

```

32  64  128
16   x   1
 8   4   2

```

If two cells have the same drop in elevation, a random cell is picked. That is not ideal as it may prevent the creation of connected flow networks. ArcGIS implements the approach of Greenlee (1987) and I might adopt that in the future.

The terrain indices are according to Wilson et al. (2007), as in `gdaldem`. TRI (Terrain Ruggedness Index) is the mean of the absolute differences between the value of a cell and the value of its 8 surrounding cells. TPI (Topographic Position Index) is the difference between the value of a cell and the mean value of its 8 surrounding cells. Roughness is the difference between the maximum and the minimum value of a cell and its 8 surrounding cells.

Such measures can also be computed with the `focal` function:

```

f <- matrix(1, nrow=3, ncol=3)
TRI <- focal(x, w=f, fun=function(x, ...) sum(abs(x[-5]-x[5]))/8)
TPI <- focal(x, w=f, fun=function(x, ...) x[5] - mean(x[-5]))
rough <- focal(x, w=f, fun=function(x, ...) max(x) - min(x), na.rm=TRUE)

```

References

- Burrough, P., and R.A. McDonnell, 1998. Principles of Geographical Information Systems. Oxford University Press.
- Fleming, M.D. and Hoffer, R.M., 1979. Machine processing of landsat MSS data and DMA topographic data for forest cover type mapping. LARS Technical Report 062879. Laboratory for Applications of Remote Sensing, Purdue University, West Lafayette, Indiana.
- Horn, B.K.P., 1981. Hill shading and the reflectance map. Proceedings of the IEEE 69:14-47
- Jones, K.H., 1998. A comparison of algorithms used to compute hill terrain as a property of the DEM. Computers & Geosciences 24: 315-323
- Ritter, P., 1987. A vector-based terrain and aspect generation algorithm. Photogrammetric Engineering and Remote Sensing 53: 1109-1111

text

Add labels to a map

Description

Plots labels, that is a textual (rather than color) representation of values, on top an existing plot (map).

Usage

```
## S4 method for signature 'SpatRaster'
text(x, labels, digits=0, halo=FALSE, ...)

## S4 method for signature 'SpatVector'
text(x, labels, halo=FALSE, ...)
```

Arguments

x	SpatRaster or SpatVector
labels	character. Optional. Vector of labels with length(x) or a variable name from names(x)
digits	integer. how many digits should be used?
halo	logical. If TRUE a "halo" is printed around the text. If TRUE, additional arguments hc="white" and hw=0.1 can be modified to set the colour and width of the halo
...	additional arguments to pass to graphics function text

See Also

[text](#), [plot](#)

Examples

```
r <- rast(nrows=4, ncols=4)
values(r) <- 1:ncell(r)
plot(r)
text(r)

plot(r)
text(r, halo=TRUE, hc="blue", col="white", hw=0.2)

plot(r, col=rainbow(16))
text(r, col=c("black", "white"), vfont=c("sans serif", "bold"), cex=2)
```

tighten

tighten SpatRaster or SpatRasterDataset objects

Description

Combines data sources within a SpatRaster object (that are in memory, or from the same file) to allow for faster processing.

Or combine sub-datsets into a SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
tighten(x)

## S4 method for signature 'SpatRasterDataset'
tighten(x)
```

Arguments

x SpatRaster or SpatRasterDataset

Value

SpatRaster

Examples

```
r <- rast(nrow=5, ncol=9, vals=1:45)
x <- c(r, r*2, r*3)
x
tighten(x)
```

time	<i>time of SpatRaster layers</i>
------	----------------------------------

Description

Get or set the time of the layers of a SpatRaster.

Usage

```
## S4 method for signature 'SpatRaster'
time(x)

## S4 replacement method for signature 'SpatRaster'
time(x)<-value
```

Arguments

x SpatRaster
value "Date", "POSIXt", or numeric

Value

Date

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

```
s <- rast(system.file("ex/logo.tif", package="terra"))

# Date"
d <- as.Date("2001-05-04") + 0:2
time(s) <- d
time(s)

# POSIX (time stored as seconds)
time(s) <- as.POSIXlt(d)
time(s)

# "raw" time
time(s) <- as.numeric(d)
time(s)
```

tmpFiles*Temporary files*

Description

List and optionally remove temporary files created by the terra package. These files are created when an output SpatRaster may be too large to store in memory (RAM). This can happen when no filename is provided to a function and when using functions where you cannot provide a filename.

Temporary files are automatically removed at the end of each R session that ends normally. You can use tmpFiles to see the files in the current sessions, including those that are orphaned (not connect to a SpatRaster object any more) and from other (perhaps old) sessions, and remove all the temporary files.

Usage

```
tmpFiles(current=TRUE, orphan=FALSE, old=FALSE, remove=FALSE)
```

Arguments

current	logical. If TRUE, temporary files from the current R session are included
orphan	logical. If TRUE, temporary files from the current R session that are no longer associated with a SpatRaster object (if current is TRUE these are also included)
old	logical. If TRUE, temporary files from other "R" sessions. Unless you are running multiple instances of R at the same time, these are from old (possibly crashed) R sessions and should be removed
remove	logical. If TRUE, temporary files are removed

Value

character

See Also

[terraOptions](#)

Examples

```
tmpFiles()
```

topology

sharedPaths

Description

Get the shared paths of lines or polygons

Usage

```
## S4 method for signature 'SpatVector'  
sharedPaths(x)
```

Arguments

x SpatVector of lines or polygons

Value

SpatVector

Examples

```
f <- system.file("ex/lux.shp", package="terra")  
v <- vect(f)  
plot(v, col="light gray")  
text(v, halo=TRUE)  
  
x <- sharedPaths(v)  
lines(x, col="red", lwd=2)  
text(x, col="blue", halo=TRUE, cex=0.8)  
head(x)
```

transpose

Transpose

Description

Transpose a SpatRaster

Usage

```
## S4 method for signature 'SpatRaster'  
t(x)  
  
## S4 method for signature 'SpatVector'  
t(x)  
  
## S4 method for signature 'SpatRaster'  
trans(x, filename="", ...)
```

Arguments

x	SpatRaster
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

See Also

[flip](#), [rotate](#)

Examples

```
r <- rast(nrows=18, ncols=36)  
values(r) <- 1:ncell(r)  
tr1 <- t(r)  
tr2 <- trans(r)  
ttr <- trans(tr2)
```

trim	<i>Trim a SpatRaster</i>
------	--------------------------

Description

Trim (shrink) a SpatRaster by removing outer rows and columns that are NA or another value.

Usage

```
## S4 method for signature 'SpatRaster'
trim(x, padding=0, value=NA, filename="", ...)
```

Arguments

x	SpatRaster
padding	integer. Number of outer rows/columns to keep
value	numeric. The value of outer rows or columns that are to be removed
filename	character. Output filename
...	additional arguments for writing files as in writeRaster

Value

SpatRaster

Examples

```
r <- rast(ncols=10, nrows=10, xmin=0,xmax=10,ymin=0,ymax=10)
v <- rep(NA, ncell(r))
v[c(12,34,69)] <- 1:3
values(r) <- v
s <- trim(r)
```

union	<i>Union SpatVector or SpatExtent objects</i>
-------	---

Description

Overlapping polygons (between, not within, objects) are intersected. Union for lines and points simply combines the two data sets; without any geometric intersections. This is equivalent to `c`. Attributes are joined. See `c` if you want to combine polygons without intersection.

If `codex` and `y` have a different geometry type, a SpatVectorCollection is returned.

If a single SpatVector is supplied, overlapping polygons are intersected. Original attributes are lost. New attributes allow for determining how many, and which, polygons overlapped.

SpatExtent: Objects are combined into their union; this is equivalent to `+`.

Usage

```
## S4 method for signature 'SpatVector,SpatVector'
union(x, y)

## S4 method for signature 'SpatVector,missing'
union(x, y)

## S4 method for signature 'SpatExtent,SpatExtent'
union(x, y)
```

Arguments

x	SpatVector or SpatExtent
y	Same as x or missing

Value

SpatVector or SpatExtent

See Also

[intersect](#))

[merge](#) and [mosaic](#) to union SpatRaster objects.

[crop](#) and [extend](#) for the union of SpatRaster and SpatExtent.

[merge](#) for merging a data.frame with attributes of a SpatVector.

Examples

```
e1 <- ext(-10, 10, -20, 20)
e2 <- ext(0, 20, -40, 5)
union(e1, e2)

#SpatVector
v <- vect(system.file("ex/lux.shp", package="terra"))
v <- v[,3:4]
p <- vect(c("POLYGON ((5.8 49.8, 6 49.9, 6.15 49.8, 6 49.65, 5.8 49.8))",
"POLYGON ((6.3 49.9, 6.2 49.7, 6.3 49.6, 6.5 49.8, 6.3 49.9))"), crs=crs(v))
values(p) <- data.frame(pid=1:2, value=expance(p))
#u <- union(v, p)
#plot(u, "pid")

#b <- buffer(v, .015)
#u <- union(b)
#u$sum <- rowSums(as.data.frame(u))
#plot(u, "sum")
```

unique	<i>Unique values</i>
--------	----------------------

Description

This function returns the unique values in a `SpatRaster` or removes duplicates in a `SpatVector`.

Usage

```
## S4 method for signature 'SpatRaster'
unique(x, incomparables=FALSE)

## S4 method for signature 'SpatVector'
unique(x, incomparables=FALSE, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatVector</code>
<code>incomparables</code>	logical. If <code>FALSE</code> and <code>x</code> is a <code>SpatRaster</code> : the unique values are determined for all layers together, and the result is a matrix. If <code>TRUE</code> , each layer is evaluated separately, and a list is returned. If <code>x</code> is a <code>SpatVector</code> this argument is as for a <code>data.frame</code> .
<code>...</code>	additional arguments passed on to <code>unique</code>

Value

If `x` is a `SpatRaster`: `data.frame` or list (if `incomparables=FALSE`)

If `x` is a `SpatVector`: `SpatVector`

Examples

```
r <- rast(ncols=5, nrows=5)
values(r) <- rep(1:5, each=5)
unique(r)
s <- c(r, round(r/3))
unique(s)
unique(s,TRUE)

v <- vect(cbind(x=c(1:5,1:5), y=c(5:1,5:1)),
crs="+proj=utm +zone=1 +datum=WGS84")
nrow(v)
u <- unique(v)
nrow(u)

values(v) <- c(1:5, 1:3, 5:4)
unique(v)
```

units	<i>units of SpatRaster or SpatRasterDataSet</i>
-------	---

Description

Get or set the units of the layers of a SpatRaster or the datasets in a SpatRasterDataSet.

Usage

```
## S4 method for signature 'SpatRaster'  
units(x)  
  
## S4 replacement method for signature 'SpatRaster'  
units(x)<-value  
  
## S4 method for signature 'SpatRasterDataset'  
units(x)  
  
## S4 replacement method for signature 'SpatRasterDataset'  
units(x)<-value
```

Arguments

x	SpatRaster
value	character

Value

character

See Also

[time, names](#)

Examples

```
s <- rast(system.file("ex/logo.tif", package="terra"))  
  
units(s) <- c("m/s", "kg", "ha")  
units(s)  
s  
  
units(s) <- "kg"  
units(s)
```

values

Cell values and geometry attributes

Description

Get the cell values of a `SpatRaster` or the attributes of a `SpatVector`

Usage

```
## S4 method for signature 'SpatRaster'
values(x, mat=TRUE, dataframe=FALSE, row=1, nrows=nrow(x), col=1, ncols=ncol(x))
```

```
## S4 method for signature 'SpatVector'
values(x)
```

Arguments

x	SpatRaster or SpatVector
mat	logical. If TRUE, values are returned as a matrix instead of as a vector, except when dataframe is TRUE
dataframe	logical. If TRUE, values are returned as a data.frame instead of as a vector (also if matrix is TRUE)
row	positive integer. Row number to start from, should be between 1 and nrow(x)
nrows	positive integer. How many rows?
col	positive integer. Column number to start from, should be between 1 and ncol(x)
ncols	positive integer. How many columns? Default is the number of columns left after the start column

Details

If `x` is a `SpatRaster`, and `mat=FALSE`, the values are returned as a vector. In cell-order by layer. If `mat=TRUE`, a matrix is returned in which the values of each layer are represented by a column (with `ncell(x)` rows). The values per layer are in cell-order, that is, from top-left, to top-right and then down by row. Use `as.matrix(x, wide=TRUE)` for an alternative matrix representation where the number of rows and columns matches that of `x`.

Value

matrix or data.frame

See Also

[values<-](#), [focalValues](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
r
x <- values(r)
x[3650:3655, ]
r[3650:3655]
```

```
ff <- system.file("ex/lux.shp", package="terra")
v <- vect(ff)
y <- values(v)
head(y)
```

vect

Create SpatVector objects

Description

Create a SpatVector

Usage

```
## S4 method for signature 'character'
vect(x, layer="", query="", extent=NULL, filter=NULL, crs="")

## S4 method for signature 'matrix'
vect(x, type="points", atts=NULL, crs="")

## S4 method for signature 'data.frame'
vect(x, geom=c("lon", "lat"), crs="")

## S4 method for signature 'sf'
vect(x)
```

Arguments

x	character. A filename; or a "Well Known Text" string; or a data.frame (only to make a SpatVector of points); or a "geom" matrix to make a SpatVector of any supported geometry (see examples and geom); or a spatial vector data object defined in the sf or sp packages
layer	character. layer name to select a layer from a file (database) with multiple layers
query	character. An query to subset the dataset in the OGR-SQL dialect
extent	Spat* object. The extent of the object is used as a spatial filter to select the geometries to read. Ignored if filter is not NULL
filter	SpatVector. Used as a spatial filter to select geometries to read (the convex hull is used for lines or points)

type	character. Geometry type. Must be "points", "lines", or "polygons"
atts	data.frame with the attributes. The number of rows must match the number of geometrical elements
crs	the coordinate reference system in one of the following formats: WKT/WKT2, <authority>:<code>, or PROJ-string notation (see link{crs})
geom	the field name(s) with the geometry data. Either two names for x and y coordinates of points, or a single name for a single column with WKT geometries)

Value

SpatVector

See Also

[geom](#)

Examples

```
### SpatVector from file
f <- system.file("ex/lux.shp", package="terra")
f
v <- vect(f)
v

## subsetting (large) files
## with attribute query
v <- vect(f, query="SELECT NAME_1, NAME_2, ID_2 FROM lux WHERE ID_2 < 4")
v

## with an extent
e <- ext(5.9, 6.3, 49.9, 50)
v <- vect(f, extent=e)

## with polygons
p <- as.polygons(e)
v <- vect(f, filter=p)

### SpatVector from a geom matrix
x1 <- rbind(c(-180,-20), c(-140,55), c(10, 0), c(-140,-60))
x2 <- rbind(c(-10,0), c(140,60), c(160,0), c(140,-55))
x3 <- rbind(c(-125,0), c(0,60), c(40,5), c(15,-45))
hole <- rbind(c(80,0), c(105,13), c(120,2), c(105,-13))
z <- rbind(cbind(object=1, part=1, x1, hole=0), cbind(object=2, part=1, x3, hole=0),
cbind(object=3, part=1, x2, hole=0), cbind(object=3, part=1, hole, hole=1))
colnames(z)[3:4] <- c('x', 'y')

p <- vect(z, "polygons")
p

z[z[, "hole"]==1, "object"] <- 4
```

```

lms <- vect(z[,1:4], "lines")
plot(p)
lines(lms, col="red", lwd=2)

### from wkt
v <- vect("POLYGON ((0 -5, 10 0, 10 -10, 0 -5))")

wkt <- c("MULTIPOLYGON ( ((40 40, 20 45, 45 30, 40 40)),
((20 35, 10 30, 10 10, 30 5, 45 20, 20 35),(30 20, 20 15, 20 25, 30 20)))",
"POLYGON ((0 -5, 10 0, 10 -10, 0 -5))")
w <- vect(wkt)

# combine two SpatVectors
vw <- rbind(w, v)

# add a data.frame
d <- data.frame(id=1:2, name=c("a", "b"))
values(w) <- d

# add data.frame on creation, here from a geom matrix
g <- geom(w)
d <- data.frame(id=1:2, name=c("a", "b"))
m <- vect(g, "polygons", atts=d, crs="+proj=longlat +datum=WGS84")

### SpatVector from a data.frame
d$wkt <- wkt
x <- vect(d, geom="wkt")

d$wkt <- NULL
d$lon <- c(0,10)
d$lat <- c(0,10)
x <- vect(d, geom=c("lon", "lat"))

# SpatVector to sf
#sf::st_as_sf(x)

```

vector-attributes

Get or replace attribute values of a SpatVector

Description

Replace values of a SpatVector.

Usage

```

## S4 method for signature 'SpatVector'
x$name

## S4 replacement method for signature 'SpatVector'
x$name<-value

```

Arguments

x	SpatVector
name	character (field name) or numeric (column number)
value	vector of new values

Value

vector

See Also

[values](#)

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
v$NAME_1
v$NAME_1[3] <- "my name"
v$ID_1 <- LETTERS[1:12]
v$new <- sample(12)
values(v)

v[2,2] <- "hello"
v[1,] <- v[10,]
v[,3] <- v[,1]
v[2, "NAME_2"] <- "terra"
head(v, 3)
```

voronoi

Voronoi diagram and Delauny triangles

Description

Get a voronoi diagram or delauny triangles for points, or the nodes of lines or polygons

Usage

```
## S4 method for signature 'SpatVector'
voronoi(x, bnd=NULL, tolerance=0, as.lines=FALSE, deldir=FALSE)

## S4 method for signature 'SpatVector'
delauny(x, tolerance=0, as.lines=FALSE)
```

Arguments

x	SpatVector
bnd	SpatVector to set the outer boundary of the voronoi diagram
tolerance	numeric ≥ 0 , snapping tolerance (0 is no snapping)
as.lines	logical. If TRUE, lines are returned without the outer boundary
deldir	logical. If TRUE, the <code>deldir</code> is used instead of the GEOS C++ library method. It has been reported that <code>deldir</code> does not choke on very large data sets

Value

SpatVector

Examples

```
wkt <- c("MULTIPOLYGON ( ((40 40, 20 45, 45 30, 40 40)),
  ((20 35, 10 30, 10 10, 30 5, 45 20, 20 35),(30 20, 20 15, 20 25, 30 20)))",
  "POLYGON ((0 -5, 10 0, 10 -10, 0 -5))")
x <- vect(wkt)
v <- voronoi(x)
v

plot(v, lwd=2, col=rainbow(15))
lines(x, col="gray", lwd=2)
points(x)
```

vrt

Virtual Raster Tiles

Description

Create a Virtual Raster Tiles (VRT) dataset from file-based raster datasets.

Usage

```
## S4 method for signature 'character'
vrt(x, filename="", overwrite=FALSE)
```

Arguments

x	character. Filenames of raster "tiles". See tiles
filename	character. Output VRT filename
overwrite	logical. Should filename be overwritten if it exists?

Value

SpatRaster

Examples

```

r <- rast(ncols=100, nrows=100)
values(r) <- 1:ncell(r)
x <- rast(ncols=2, nrows=2)
filename <- paste0(tempfile(), "_tif")
ff <- makeTiles(r, x, filename)
ff

vrtfile <- paste0(tempfile(), ".vrt")
v <- vrt(ff, vrtfile)
head(readLines(vrtfile))
v

```

weighted.mean	<i>Weighted mean of layers</i>
---------------	--------------------------------

Description

Compute the weighted mean for each cell of the layers of a `SpatRaster`. The weights can be spatially variable or not.

Usage

```

## S4 method for signature 'SpatRaster,numeric'
weighted.mean(x, w, na.rm=FALSE, filename="", ...)

## S4 method for signature 'SpatRaster,SpatRaster'
weighted.mean(x, w, na.rm=FALSE, filename="", ...)

```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>w</code>	A vector of weights (one number for each layer), or for spatially variable weights, a <code>SpatRaster</code> with weights (should have the same extent, resolution and number of layers as <code>x</code>)
<code>na.rm</code>	Logical. Should missing values be removed?
<code>filename</code>	character. Output filename
<code>...</code>	options for writing files as in writeRaster

Value

`SpatRaster`

See Also

[Summary-methods](#), [weighted.mean](#)

Examples

```

b <- rast(system.file("ex/logo.tif", package="terra"))

# give least weight to first layer, most to last layer
wm1 <- weighted.mean(b, w=1:3)

# spatially varying weights
# weigh by column number
w1 <- init(b, "col")

# weigh by row number
w2 <- init(b, "row")
w <- c(w1, w2, w2)

wm2 <- weighted.mean(b, w=w)

```

which.lyr

Which cells are TRUE?

Description

This method returns a single layer `SpatRaster` with cell values that are the first layer in the input that has the value is not zero (`FALSE`), and, hence, is `TRUE`.

Usage

```

## S4 method for signature 'SpatRaster'
which.lyr(x)

```

Arguments

x `SpatRaster`

Value

`SpatRaster`

See Also

[isTRUE](#), [which](#), See [Summary-methods](#) for `which.min` and `which.max`

Examples

```

s <- rast(system.file("ex/logo.tif", package="terra"))
x <- which.lyr(s > 100)

```

window	<i>Set a window</i>
--------	---------------------

Description

Experimental: Assign a window (area of interest) to a `SpatRaster` with a `SpatExtent`, or set it to `NULL` to remove the window. This is similar to `crop` without actually creating a new dataset.

Currently, the window will be forced to intersect with the extent of the `SpatRaster`. It is envisioned that in future versions, the window may also go outside these boundaries.

Usage

```
## S4 replacement method for signature 'SpatRaster'  
window(x) <- value  
  
## S4 method for signature 'SpatRaster'  
window(x)
```

Arguments

x	<code>SpatRaster</code>
value	<code>SpatExtent</code>

Value

none for `window<-` and logical for `window`

See Also

[crop](#), [extend](#)

Examples

```
f <- system.file("ex/elev.tif", package="terra")  
r <- rast(f)  
global(r, "mean", na.rm=TRUE)  
e <- ext(c(5.9, 6, 49.95, 50))  
  
window(r) <- e  
global(r, "mean", na.rm=TRUE)  
r  
  
x <- rast(f)  
xe <- crop(x, e)  
global(xe, "mean", na.rm=TRUE)  
  
b <- c(xe, r)
```

```
window(b)
b

window(r) <- NULL
r
```

wrap

wrap (pack) a SpatRaster or SpatVector object

Description

Wrap a SpatRaster or SpatVector object to create a Packed* object that it can be saved as an R object to disk, or passed over a connection that serializes (e.g. using a computer cluster).

Usage

```
## S4 method for signature 'SpatRaster'
wrap(x)

## S4 method for signature 'SpatVector'
wrap(x)
```

Arguments

x SpatVector or SpatRaster

Value

Packed* object

Examples

```
f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
p <- wrap(v)
p
vv <- vect(p)
vv
```

writeCDF	<i>Write raster data to a NetCDF file</i>
----------	---

Description

Write a `SpatRaster` or `SpatRasterDataset` to a NetCDF file.

When using a `SpatRasterDataset`, the `varname`, `longname`, and `unit` should be set in the object (see examples).

Always use the ".nc" or ".cdf" file extension to assure that the file can be properly read again by GDAL

Usage

```
## S4 method for signature 'SpatRaster'
writeCDF(x, filename, varname, longname="", unit="", ...)
```

```
## S4 method for signature 'SpatRasterDataset'
writeCDF(x, filename, overwrite=FALSE, zname="time",
         prec="float", compression=NA, missval, ...)
```

Arguments

<code>x</code>	<code>SpatRaster</code> or <code>SpatRasterDataset</code>
<code>filename</code>	character. Output filename
<code>varname</code>	character. Name of the dataset
<code>longname</code>	character. Long name of the dataset
<code>unit</code>	character. Unit of the data
<code>overwrite</code>	logical. If TRUE, filename is overwritten
<code>zname</code>	character. The name of the "time" dimension
<code>prec</code>	character. One of "double", "float", "integer", "short", "byte" or "char"
<code>compression</code>	Can be set to an integer between 1 (least compression) and 9 (most compression)
<code>missval</code>	numeric, the number used to indicate missing values
<code>...</code>	additional arguments passed on to <code>ncvar_def</code>

Value

`SpatRaster` or `SpatDataSet`

See Also

see [writeRaster](#) for writing other file formats

Examples

```
f <- system.file("ex/elev.tif", package="terra")
r <- rast(f)
fname <- paste0(tempfile(), ".nc")
rr <- writeCDF(r, fname, overwrite=TRUE, varname="alt",
              longname="elevation in m above sea level", unit="m")

a <- rast(ncols=5, nrows=5, nl=50)
values(a) <- 1:prod(dim(a))
time(a) <- as.Date("2020-12-31") + 1:nlyr(a)
aa <- writeCDF(a, fname, overwrite=TRUE, varname="power",
              longname="my nice data", unit="U/Pa")

b <- sqrt(a)
s <- sds(a, b)
names(s) <- c("temp", "prec")
longnames(s) <- c("temperature (C)", "precipitation (mm)")
units(s) <- c("C", "mm")
ss <- writeCDF(s, fname, overwrite=TRUE)

# for CRAN
file.remove(fname)
```

writeRaster

Write raster data to a file

Description

Write a SpatRaster object to a file.

Usage

```
## S4 method for signature 'SpatRaster,character'
writeRaster(x, filename, overwrite=FALSE, ...)
```

Arguments

x	SpatRaster
filename	character. Output filename. Can be a single filename, or as many filenames as nlyr(x) to write a file for each layer
overwrite	logical. If TRUE, filename is overwritten
...	additional arguments for for writing files. See Details

Details

In writeRaster, and in other methods that generate SpatRaster objects, options for writing raster files to disk can be provided as additional arguments or, in a few cases, as the wopt argument (a named list) if the additional arguments are already used for a different purpose. The following options are available:

name	description
datatype	values for datatype are "INT1U", "INT2U", "INT2S", "INT4U", "INT4S", "FLT4S", "FLT8S". The first three le
filetype	file format expresses as GDAL driver names . If this argument is not supplied, the driver is derived from the filena
gdal	GDAL driver specific datasource creation options. See the GDAL documentation. For example, with the GeoTiff
tempdir	the path where temporary files are to be written to.
progress	positive integer. If the number of chunks is larger, a progress bar is shown.
memfrac	numeric between 0.1 and 0.9. The fraction of available RAM that terra is allowed to use.
names	output layer names.
NAflag	numeric. value to represent missing (NA or NaN) values. See note
verbose	logical. If TRUE debugging information is printed.
todisk	logical. If TRUE processing operates as if the dataset is very large and needs to be written to a temporary file (for c

Value

SpatRaster. This function is used for the side-effect of writing values to a file.

Note

GeoTiff files are, by default, written with LZW compression. If you do not want compression, use `gdal="COMPRESS=NONE"`.

When writing integer values the lowest available value (given the datatype) is used to represent NA for signed types, and the highest value is used for unsigned values. This can be a problem with byte data (between 0 and 255) as the value 255 is reserved for NA. To keep the value 255, you need to set another value as `NAflag`, or do not set a `NAflag` (with `NAflag=NA`)

See Also

see [writeCDF](#) for writing NetCDF files.

Examples

```
library(terra)
r <- rast(nrows=5, ncols=5, vals=1:25)

# create a temporary filename for the example
f <- file.path(tempdir(), "test.tif")

writeRaster(r, f, overwrite=TRUE)

writeRaster(r, f, overwrite=TRUE, gdal=c("COMPRESS=NONE", "TFW=YES", "of=COG"), datatype='INT1U')

## Or with a wopt argument:

writeRaster(r, f, overwrite=TRUE, wopt= list(gdal=c("COMPRESS=NONE", "of=COG"), datatype='INT1U'))

## remove the file
unlink(f)
```

writeVector	<i>Write SpatVector data to a file</i>
-------------	--

Description

Write a SpatVector to a file. You can choose one of many file formats.

Usage

```
## S4 method for signature 'SpatVector,character'
writeVector(x, filename, filetype="ESRI Shapefile", overwrite=FALSE)
```

Arguments

x	SpatVector
filename	character. Output filename
filetype	character. A file format associated with a GDAL "driver". See <code>gdal(drivers=TRUE)</code>
overwrite	logical. If TRUE, filename is overwritten

Examples

```
v <- vect(cbind(1:5,1:5))
crs(v) <- "+proj=longlat +datum=WGS84"
v$id <- 1:length(v)
v$name <- letters[1:length(v)]
tmpf1 <- tempfile()
writeVector(v, tmpf1)
x <- vect(tmpf1)

f <- system.file("ex/lux.shp", package="terra")
v <- vect(f)
tmpf2 <- tempfile()
writeVector(v, tmpf2)
y <- vect(tmpf2)
```

xmin	<i>Get or set single values of an extent</i>
------	--

Description

Get or set single values of an extent. Values can be set for a SpatExtent or SpatRaster, but not for a SpatVector)

Usage

```
## S4 method for signature 'SpatExtent'  
xmin(x)  
  
## S4 method for signature 'SpatExtent'  
xmax(x)  
  
## S4 method for signature 'SpatExtent'  
ymin(x)  
  
## S4 method for signature 'SpatExtent'  
ymax(x)  
  
## S4 method for signature 'SpatRaster'  
xmin(x)  
  
## S4 method for signature 'SpatRaster'  
xmax(x)  
  
## S4 method for signature 'SpatRaster'  
ymin(x)  
  
## S4 method for signature 'SpatRaster'  
ymax(x)  
  
## S4 method for signature 'SpatVector'  
xmin(x)  
  
## S4 method for signature 'SpatVector'  
xmax(x)  
  
## S4 method for signature 'SpatVector'  
ymin(x)  
  
## S4 method for signature 'SpatVector'  
ymax(x)  
  
## S4 replacement method for signature 'SpatRaster,numeric'  
xmin(x)<-value  
  
## S4 replacement method for signature 'SpatRaster,numeric'  
xmax(x)<-value  
  
## S4 replacement method for signature 'SpatRaster,numeric'  
ymin(x)<-value  
  
## S4 replacement method for signature 'SpatRaster,numeric'  
ymax(x)<-value
```

Arguments

x	SpatRaster, SpatExtent, or SpatVector
value	numeric

Value

SpatExtent or numeric coordinate

Examples

```
r <- rast()
ext(r)
ext(c(0, 20, 0, 20))

xmin(r)
xmin(r) <- 0
xmin(r)
```

xyRowColCell

Coordinates from a row, column or cell number and vice versa

Description

Get coordinates of the center of raster cells for a row, column, or cell number of a SpatRaster object. Or get row, column, or cell numbers from coordinates or from each other.

Cell numbers start at 1 in the upper left corner, and increase from left to right, and then from top to bottom. The last cell number equals the number of cells of the SpatRaster object. row numbers start at 1 at the top, column numbers start at 1 at the left.

Usage

```
## S4 method for signature 'SpatRaster,numeric'
xFromCol(object, col)

## S4 method for signature 'SpatRaster,numeric'
yFromRow(object, row)

## S4 method for signature 'SpatRaster,numeric'
xyFromCell(object, cell)

## S4 method for signature 'SpatRaster,numeric'
xFromCell(object, cell)

## S4 method for signature 'SpatRaster,numeric'
yFromCell(object, cell)

## S4 method for signature 'SpatRaster,numeric'
```



```

colFromX(object, x)

## S4 method for signature 'SpatRaster,numeric'
rowFromY(object, y)

## S4 method for signature 'SpatRaster,numeric,numeric'
cellFromRowCol(object, row, col)

## S4 method for signature 'SpatRaster,numeric,numeric'
cellFromRowColCombine(object, row, col)

## S4 method for signature 'SpatRaster,numeric'
rowFromCell(object, cell)

## S4 method for signature 'SpatRaster,numeric'
colFromCell(object, cell)

## S4 method for signature 'SpatRaster,numeric'
rowColFromCell(object, cell)

## S4 method for signature 'SpatRaster,matrix'
cellFromXY(object, xy)

```

Arguments

object	SpatRaster
cell	integer. cell number(s)
col	integer. column number(s)
row	integer row number(s)
x	x coordinate(s)
y	y coordinate(s)
xy	matrix of x and y coordinates

Details

Cell numbers start at 1 in the upper left corner, and increase from left to right, and then from top to bottom. The last cell number equals the number of cells of the SpatRaster (see [ncell](#)).

Value

xFromCol, yFromCol, xFromCell, yFromCell: vector of x or y coordinates
xyFromCell: matrix(x,y) with coordinate pairs
colFromX, rowFromY, cellFromXY, cellFromRowCol, rowFromCell, colFromCell: vector of row, column, or cell numbers
rowColFromCell: matrix of row and column numbers

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

```

r <- rast()

xFromCol(r, c(1, 120, 180))
yFromRow(r, 90)
xyFromCell(r, 10000)
xyFromCell(r, c(0, 1, 32581, ncell(r), ncell(r)+1))

cellFromRowCol(r, 5, 5)
cellFromRowCol(r, 1:2, 1:2)
cellFromRowCol(r, 1, 1:3)

# all combinations
cellFromRowColCombine(r, 1:2, 1:2)

colFromX(r, 10)
rowFromY(r, 10)
xy <- cbind(lon=c(10,5), lat=c(15, 88))
cellFromXY(r, xy)

```

zonal

*Zonal statistics***Description**

Compute zonal statistics, that is summarized values of a `SpatRaster` for each "zone" defined by another `SpatRaster`.

If `fun` is a true function, `zonal` may fail for very large `SpatRaster` objects, except for the functions ("mean", "min", "max", or "sum").

Usage

```

## S4 method for signature 'SpatRaster,SpatRaster'
zonal(x, z, fun=mean, ..., as.raster=FALSE, filename="", wopt=list())

```

Arguments

<code>x</code>	<code>SpatRaster</code>
<code>z</code>	<code>SpatRaster</code> with values representing zones
<code>fun</code>	function to be applied to summarize the values by zone. Either as character: "mean", "min", "max", "sum", or, for relatively small <code>SpatRasters</code> , a proper function
<code>...</code>	additional arguments passed to <code>fun</code>

as.raster logical. If TRUE, a `SpatRaster` is returned with the zonal statistic for each zone
filename character. Output filename (ignored if `as.raster=FALSE`)
wopt list with additional arguments for writing files as in [writeRaster](#)

Value

A data.frame with a value for each zone (unique value in zones)

See Also

See [global](#) for "global" statistics (i.e., all of `x` is considered a single zone), [app](#) for local statistics, and [extract](#) for summarizing values for polygons

Examples

```

r <- rast(ncols=10, nrows=10)
values(r) <- 1:ncell(r)
z <- rast(r)
values(z) <- rep(c(1:2, NA, 3:4), each=20)
names(z) <- "zone"
zonal(r, z, "sum", na.rm=TRUE)

# multiple layers
r <- rast(system.file("ex/logo.tif", package = "terra"))
# zonal layer
z <- rast(r, 1)
names(z) <- "zone"
values(z) <- rep(c(1:2, NA, c(3:4)), each=ncell(r)/5, length.out=ncell(r))

zonal(r, z, "mean", na.rm = TRUE)

# raster of zonal values
zr <- zonal(r, z, "mean", na.rm = TRUE, as.raster=TRUE)

```

zoom

Zoom in on a map

Description

Zoom in on a map (plot) by providing a new extent, by default this is done by clicking twice on the map.

Usage

```

## S4 method for signature 'SpatRaster'
zoom(x, e=draw(), maxcell=100000, layer=1, new=FALSE, ...)

## S4 method for signature 'SpatVector'
zoom(x, e=draw(), new=FALSE, ...)

```

Arguments

x	SpatRaster
e	SpatExtent
maxcell	positive integer. Maximum number of cells used for the map
layer	positive integer to select the layer to be used
new	logical. If TRUE, the zoomed in map will appear on a new device (window)
...	additional arguments passed to plot

Value

SpatExtent (invisibly)

See Also

[draw](#), [plot](#)

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