Package: sf (via r-universe)

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Title Simple Features for R

Description Support for simple feature access, a standardized way to encode and analyze spatial vector data. Binds to 'GDAL' <doi:10.5281/zenodo.5884351> for reading and writing data, to 'GEOS' <doi:10.5281/zenodo.11396894> for geometrical operations, and to 'PROJ' <doi:10.5281/zenodo.5884394> for projection conversions and datum transformations. Uses by default the 's2' package for geometry operations on geodetic (long/lat degree) coordinates.

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BugReports https://github.com/r-spatial/sf/issues

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`aggregate.sf` *aggregate an* `sf` *object*

Description

aggregate an `sf` object, possibly union-ing geometries

Usage

```
## S3 method for class 'sf'
aggregate(
  x,
  by,
  FUN,
  ...,
  do_union = TRUE,
  simplify = TRUE,
  join = st_intersects
)
```

Arguments

`x`	object of class sf
`by`	either a list of grouping vectors with length equal to `nrow(x)` (see aggregate), or an object of class `sf` or `sfc` with geometries that are used to generate groupings, using the binary predicate specified by the argument `join`
`FUN`	function passed on to aggregate, in case `ids` was specified and attributes need to be grouped
`...`	arguments passed on to `FUN`
`do_union`	logical; should grouped geometries be unioned using st_union? See details.
`simplify`	logical; see aggregate
`join`	logical spatial predicate function to use if `by` is a simple features object or geometry; see st_join

Details

In case do_union is FALSE, aggregate will simply combine geometries using c.sfg. When polygons sharing a boundary are combined, this leads to geometries that are invalid; see https://github.com/r-spatial/sf/issues/681.

Value

an sf object with aggregated attributes and geometries; additional grouping variables having the names of names(ids) or are named Group.i for ids[[i]]; see aggregate.

Note

Does not work using the formula notation involving ~ defined in aggregate.

Examples

```
m1 = cbind(c(0, 0, 1, 0), c(0, 1, 1, 0))
m2 = cbind(c(0, 1, 1, 0), c(0, 0, 1, 0))
pol = st_sfc(st_polygon(list(m1)), st_polygon(list(m2)))
set.seed(1985)
d = data.frame(matrix(runif(15), ncol = 3))
p = st_as_sf(x = d, coords = 1:2)
plot(pol)
plot(p, add = TRUE)
(p_ag1 = aggregate(p, pol, mean))
plot(p_ag1) # geometry same as pol
# works when x overlaps multiple objects in 'by':
p_buff = st_buffer(p, 0.2)
plot(p_buff, add = TRUE)
(p_ag2 = aggregate(p_buff, pol, mean)) # increased mean of second
# with non-matching features
m3 = cbind(c(0, 0, -0.1, 0), c(0, 0.1, 0.1, 0))
pol = st_sfc(st_polygon(list(m3)), st_polygon(list(m1)), st_polygon(list(m2)))
(p_ag3 = aggregate(p, pol, mean))
plot(p_ag3)
# In case we need to pass an argument to the join function:
(p_ag4 = aggregate(p, pol, mean,
     join = function(x, y) st_is_within_distance(x, y, dist = 0.3)))
```

---

as *Methods to coerce simple features to* Spatial* *and* Spatial*DataFrame *objects*

Description

as_Spatial() allows to convert sf and sfc to Spatial*DataFrame and Spatial* for sp compatibility. You can also use as(x, "Spatial") To transform sp objects to sf and sfc with as(x, "sf").

Usage

```
as_Spatial(from, cast = TRUE, IDs = paste0("ID", seq_along(from)))
```

Arguments

from	object of class sf, sfc_POINT, sfc_MULTIPOINT, sfc_LINESTRING, sfc_MULTILINESTRING, sfc_POLYGON, or sfc_MULTIPOLYGON.
cast	logical; if TRUE, st_cast() from before converting, so that e.g. GEOMETRY objects with a mix of POLYGON and MULTIPOLYGON are cast to MULTIPOLYGON.
IDs	character vector with IDs for the Spatial* geometries

Details

Package sp supports three dimensions for POINT and MULTIPOINT (SpatialPoint*). Other geometries must be two-dimensional (XY). Dimensions can be dropped using st_zm() with what = "M" or what = "ZM".

For converting simple features (i.e., sf objects) to their Spatial counterpart, use as(obj, "Spatial")

Value

geometry-only object deriving from Spatial, of the appropriate class

Examples

```
nc <- st_read(system.file("shape/nc.shp", package="sf"))
if (require(sp, quietly = TRUE)) {
# convert to SpatialPolygonsDataFrame
spdf <- as_Spatial(nc)
# identical to
spdf <- as(nc, "Spatial")
# convert to SpatialPolygons
as(st_geometry(nc), "Spatial")
# back to sf
as(spdf, "sf")
}
```

---

bind *Bind rows (features) of sf objects*

Description

Bind rows (features) of sf objects

Bind columns (variables) of sf objects

Usage

```
## S3 method for class 'sf'
rbind(..., deparse.level = 1)

## S3 method for class 'sf'
cbind(..., deparse.level = 1, sf_column_name = NULL)

st_bind_cols(...)
```

Arguments

...	objects to bind; note that for the rbind and cbind methods, all objects have to be of class sf; see dotsMethods
deparse.level	integer; see rbind
sf_column_name	character; specifies active geometry; passed on to st_sf

Details

both rbind and cbind have non-standard method dispatch (see cbind): the rbind or cbind method for sf objects is only called when all arguments to be binded are of class sf.

If you need to cbind e.g. a data.frame to an sf, use data.frame directly and use st_sf on its result, or use bind_cols; see examples.

st_bind_cols is deprecated; use cbind instead.

Value

cbind called with multiple sf objects warns about multiple geometry columns present when the geometry column to use is not specified by using argument sf_column_name; see also st_sf.

Examples

```
crs = st_crs(3857)
a = st_sf(a=1, geom = st_sfc(st_point(0:1)), crs = crs)
b = st_sf(a=1, geom = st_sfc(st_linestring(matrix(1:4,2))), crs = crs)
c = st_sf(a=4, geom = st_sfc(st_multilinestring(list(matrix(1:4,2)))), crs = crs)
rbind(a,b,c)
rbind(a,b)
rbind(a,b)
rbind(b,c)
cbind(a,b,c) # warns
if (require(dplyr, quietly = TRUE))
  dplyr::bind_cols(a,b)
c = st_sf(a=4, geomc = st_sfc(st_multilinestring(list(matrix(1:4,2)))), crs = crs)
cbind(a,b,c, sf_column_name = "geomc")
df = data.frame(x=3)
st_sf(data.frame(c, df))
if (require(dplyr, quietly = TRUE))
  dplyr::bind_cols(c, df)
```

db_drivers *Drivers for which update should be* TRUE *by default*

Description

Drivers for which update should be TRUE by default

Usage

```
db_drivers
```

dbDataType,PostgreSQLConnection,sf-method *Determine database type for R vector*

Description

Determine database type for R vector

Determine database type for R vector

Usage

```
## S4 method for signature 'PostgreSQLConnection,sf'
dbDataType(dbObj, obj)

## S4 method for signature 'DBIObject,sf'
dbDataType(dbObj, obj)
```

Arguments

dbObj	DBIObject driver or connection.
obj	Object to convert

dbWriteTable,PostgreSQLConnection,character,sf-method
Write sf *object to Database*

Description

Write sf object to Database

Write sf object to Database

Usage

```
## S4 method for signature 'PostgreSQLConnection,character,sf'
dbWriteTable(
  conn,
  name,
  value,
  ...,
  row.names = FALSE,
  overwrite = FALSE,
  append = FALSE,
  field.types = NULL,
  binary = TRUE
)

## S4 method for signature 'DBIObject,character,sf'
dbWriteTable(
  conn,
  name,
  value,
  ...,
  row.names = FALSE,
  overwrite = FALSE,
  append = FALSE,
  field.types = NULL,
  binary = TRUE
)
```

Arguments

conn	DBIObject
name	character vector of names (table names, fields, keywords).
value	a data.frame.
...	placeholder for future use.
row.names	Add a row.name column, or a vector of length nrow(obj) containing row.names; default FALSE.

overwrite	Will try to drop table before writing; default FALSE.
append	Append rows to existing table; default FALSE.
field.types	default NULL. Allows to override type conversion from R to PostgreSQL. See dbDataType() for details.
binary	Send geometries serialized as Well-Known Binary (WKB); if FALSE, uses Well-Known Text (WKT). Defaults to TRUE (WKB).

---

extension_map *Map extension to driver*

Description

Map extension to driver

Usage

```
extension_map
```

---

gdal_addo *Add or remove overviews to/from a raster image*

Description

add or remove overviews to/from a raster image

Usage

```
gdal_addo(
  file,
  overviews = c(2, 4, 8, 16),
  method = "NEAREST",
  layers = integer(0),
  options = character(0),
  config_options = character(0),
  clean = FALSE,
  read_only = FALSE
)
```

Arguments

file	character; file name
overviews	integer; overview levels
method	character; method to create overview; one of: nearest, average, rms, gauss, cubic, cubicspline, lanczos, average_mp, average_magphase, mode
layers	integer; layers to create overviews for (default: all)
options	character; dataset opening options
config_options	named character vector with GDAL config options, like c(option1=value1, option2=value2)
clean	logical; if TRUE only remove overviews, do not add
read_only	logical; if TRUE, add overviews to another file with extension .ovr added to file

Value

TRUE, invisibly, on success

See Also

gdal_utils for access to other gdal utilities that have a C API

---

gdal_compressors *List GDAL compressors and decompressors*

Description

List GDAL compressors and decompressors

Usage

```
gdal_compressors()
```

Value

named list with two character vectors, containing compressors and decompressors

gdal_utils *Native interface to gdal utils*

Description

Native interface to gdal utils

Usage

```
gdal_utils(
  util = "info",
  source,
  destination,
  options = character(0),
 quiet = !(util %in% c("info", "gdalinfo", "ogrinfo", "vectorinfo", "mdiminfo")) ||
    ("-multi" %in% options),
  processing = character(0),
  colorfilename = character(0),
  config_options = character(0),
  read_only = FALSE
)
```

Arguments

util	character; one of info, warp, rasterize, translate, vectortranslate (for ogr2ogr), buildvrt, demprocessing, nearblack, grid, mdiminfo and mdimtranslate (the last two requiring GDAL 3.1), ogrinfo (requiring GDAL 3.7), footprint (requiring GDAL 3.8)
source	character; name of input layer(s); for warp, buidvrt or mdimtranslate this can be more than one
destination	character; name of output layer
options	character; options for the utility
quiet	logical; if TRUE, suppress printing the output for info and mdiminfo, and suppress printing progress
processing	character; processing options for demprocessing
colorfilename	character; name of color file for demprocessing (mandatory if processing="color-relief")
config_options	named character vector with GDAL config options, like c(option1=value1, option2=value2)
read_only	logical; only for ogrinfo: if TRUE, source is opened in read-only mode

Value

info returns a character vector with the raster metadata; all other utils return (invisibly) a logical indicating success (i.e., TRUE); in case of failure, an error is raised.

See Also

gdal_addo for adding overlays to a raster file; st_layers to query geometry type(s) and crs from layers in a (vector) data source

Examples

```
if (compareVersion(sf_extSoftVersion()["GDAL"], "2.1.0") == 1) {
# info utils can be used to list information about a raster
# dataset. More info: https://gdal.org/programs/gdalinfo.html
in_file <- system.file("tif/geomatrix.tif", package = "sf")
gdal_utils("info", in_file, options = c("-mm", "-proj4"))

# vectortranslate utils can be used to convert simple features data between
# file formats. More info: https://gdal.org/programs/ogr2ogr.html
in_file <- system.file("shape/storms_xyz.shp", package="sf")
out_file <- paste0(tempfile(), ".gpkg")
gdal_utils(
  util = "vectortranslate",
  source = in_file,
  destination = out_file, # output format must be specified for GDAL < 2.3
  options = c("-f", "GPKG")
)
# The parameters can be specified as c("name") or c("name", "value"). The
# vectortranslate utils can perform also various operations during the
# conversion process. For example, we can reproject the features during the
# translation.
gdal_utils(
  util = "vectortranslate",
  source = in_file,
  destination = out_file,
  options = c(
  "-f", "GPKG", # output file format for GDAL < 2.3
  "-s_srs", "EPSG:4326", # input file SRS
  "-t_srs", "EPSG:2264", # output file SRS
  "-overwrite"
  )
)
st_read(out_file)
# The parameter s_srs had to be specified because, in this case, the in_file
# has no associated SRS.
st_read(in_file)
}
```

---

geos_binary_ops *Geometric operations on pairs of simple feature geometry sets*

Description

Perform geometric set operations with simple feature geometry collections

Usage

```
st_intersection(x, y, ..., by_element = FALSE)

## S3 method for class 'sfc'
st_intersection(x, y, ...)

## S3 method for class 'sf'
st_intersection(x, y, ...)

st_difference(x, y, ...)

## S3 method for class 'sfc'
st_difference(x, y, ...)

st_sym_difference(x, y, ...)

st_snap(x, y, tolerance)
```

Arguments

x	object of class sf, sfc or sfg
y	object of class sf, sfc or sfg
...	arguments passed on to s2_options
by_element	logical; if TRUE, return pair-wise computed geometries, rather than set-wise; can be used for all binary operations
tolerance	tolerance values used for st_snap; numeric value or object of class units; may have tolerance values for each feature in x

Details

When using GEOS and not using s2, a spatial index is built on argument x; see https://r-spatial.org/r/2017/06/22/spatial-index.html. The reference for the STR tree algorithm is: Leutenegger, Scott T., Mario A. Lopez, and Jeffrey Edgington. "STR: A simple and efficient algorithm for R-tree packing." Data Engineering, 1997. Proceedings. 13th international conference on. IEEE, 1997. For the pdf, search Google Scholar.

When called with missing y, the sfc method for st_intersection returns all non-empty intersections of the geometries of x; an attribute idx contains a list-column with the indexes of contributing geometries.

when called with a missing y, the sf method for st_intersection returns an sf object with attributes taken from the contributing feature with lowest index; two fields are added: n.overlaps with the number of overlapping features in x, and a list-column origins with indexes of all overlapping features.

When st_difference is called with a single argument, overlapping areas are erased from geometries that are indexed at greater numbers in the argument to x; geometries that are empty or contained fully inside geometries with higher priority are removed entirely. The st_difference.sfc method

with a single argument returns an object with an "idx" attribute with the original index for returned geometries.

st_snap snaps the vertices and segments of a geometry to another geometry's vertices. If y contains more than one geometry, its geometries are merged into a collection before snapping to that collection.

(from the GEOS docs:) "A snap distance tolerance is used to control where snapping is performed. Snapping one geometry to another can improve robustness for overlay operations by eliminating nearly-coincident edges (which cause problems during noding and intersection calculation). Too much snapping can result in invalid topology being created, so the number and location of snapped vertices is decided using heuristics to determine when it is safe to snap. This can result in some potential snaps being omitted, however."

Value

The intersection, difference or symmetric difference between two sets of geometries. The returned object has the same class as that of the first argument (x) with the non-empty geometries resulting from applying the operation to all geometry pairs in x and y. In case x is of class sf, the matching attributes of the original object(s) are added. The sfc geometry list-column returned carries an attribute idx, which is an n-by-2 matrix with every row the index of the corresponding entries of x and y, respectively.

Note

To find whether pairs of simple feature geometries intersect, use the function st_intersects instead of st_intersection.

When using GEOS and not using s2 polygons contain their boundary. When using s2 this is determined by the model defaults of s2_options, which can be overridden via the ... argument, e.g. model = "closed" to force DE-9IM compliant behaviour of polygons (and reproduce GEOS results).

See Also

st_union for the union of simple features collections; intersect and setdiff for the base R set operations.

Examples

```
set.seed(131)
library(sf)
m = rbind(c(0,0), c(1,0), c(1,1), c(0,1), c(0,0))
p = st_polygon(list(m))
n = 100
l = vector("list", n)
for (i in 1:n)
  l[[i]] = p + 10 * runif(2)
s = st_sfc(l)
plot(s, col = sf.colors(categorical = TRUE, alpha = .5))
title("overlapping squares")
d = st_difference(s) # sequential differences: s1, s2-s1, s3-s2-s1, ...
plot(d, col = sf.colors(categorical = TRUE, alpha = .5))
title("non-overlapping differences")
```

```
i = st_intersection(s) # all intersections
plot(i, col = sf.colors(categorical = TRUE, alpha = .5))
title("non-overlapping intersections")
summary(lengths(st_overlaps(s, s))) # includes self-counts!
summary(lengths(st_overlaps(d, d)))
summary(lengths(st_overlaps(i, i)))
sf = st_sf(s)
i = st_intersection(sf) # all intersections
plot(i["n.overlaps"])
summary(i$n.overlaps - lengths(i$origins))
# A helper function that erases all of y from x:
st_erase = function(x, y) st_difference(x, st_union(st_combine(y)))
poly = st_polygon(list(cbind(c(0, 0, 1, 1, 0), c(0, 1, 1, 0, 0))))
lines = st_multilinestring(list(
 cbind(c(0, 1), c(1, 1.05)),
 cbind(c(0, 1), c(0, -.05)),
 cbind(c(1, .95, 1), c(1.05, .5, -.05))
))
snapped = st_snap(poly, lines, tolerance=.1)
plot(snapped, col='red')
plot(poly, border='green', add=TRUE)
plot(lines, lwd=2, col='blue', add=TRUE)
```

---

geos_binary_pred *Geometric binary predicates on pairs of simple feature geometry sets*

Description

Geometric binary predicates on pairs of simple feature geometry sets

Usage

```
st_intersects(x, y, sparse = TRUE, ..., by_element = FALSE)

st_disjoint(x, y = x, sparse = TRUE, prepared = TRUE, ...)

st_touches(x, y, sparse = TRUE, prepared = TRUE, ...)

st_crosses(x, y, sparse = TRUE, prepared = TRUE, ...)

st_within(x, y, sparse = TRUE, prepared = TRUE, ...)

st_contains(x, y, sparse = TRUE, prepared = TRUE, ..., model = "open")

st_contains_properly(x, y, sparse = TRUE, prepared = TRUE, ...)

st_overlaps(x, y, sparse = TRUE, prepared = TRUE, ...)

st_equals(
```

```
  x,
  y,
  sparse = TRUE,
  prepared = FALSE,
  ...,
  retain_unique = FALSE,
  remove_self = FALSE
)

st_covers(x, y, sparse = TRUE, prepared = TRUE, ..., model = "closed")

st_covered_by(x, y = x, sparse = TRUE, prepared = TRUE, ..., model = "closed")

st_equals_exact(x, y, par, sparse = TRUE, prepared = FALSE, ...)

st_is_within_distance(x, y = x, dist, sparse = TRUE, ..., remove_self = FALSE)
```

Arguments

x	object of class sf, sfc or sfg
y	object of class sf, sfc or sfg; if missing, x is used
sparse	logical; should a sparse index list be returned (TRUE) or a dense logical matrix? See below.
...	Arguments passed on to s2::s2_options snap Use s2_snap_identity(), s2_snap_distance(), s2_snap_level(), or s2_snap_precision() to specify how or if coordinate rounding should occur. snap_radius As opposed to the snap function, which specifies the maximum distance a vertex should move, the snap radius (in radians) sets the minimum distance between vertices of the output that don't cause vertices to move more than the distance specified by the snap function. This can be used to simplify the result of a boolean operation. Use -1 to specify that any minimum distance is acceptable. duplicate_edges Use TRUE to keep duplicate edges (e.g., duplicate points). edge_type One of 'directed' (default) or 'undirected'. validate Use TRUE to validate the result from the builder. polyline_type One of 'path' (default) or 'walk'. If 'walk', polylines that backtrack are preserved. polyline_sibling_pairs One of 'discard' (default) or 'keep'. simplify_edge_chains Use TRUE to remove vertices that are within snap_radius of the original vertex. split_crossing_edges Use TRUE to split crossing polyline edges when creating geometries. idempotent Use FALSE to apply snap even if snapping is not necessary to satisfy vertex constraints. dimensions A combination of 'point', 'polyline', and/or 'polygon' that can used to constrain the output of s2_rebuild() or a boolean operation.

`level` A value from 0 to 30 corresponding to the cell level at which snapping should occur.

`precision` A number by which coordinates should be multiplied before being rounded. Rounded to the nearest exponent of 10.

`distance` A distance (in radians) denoting the maximum distance a vertex should move in the snapping process.

`by_element` logical; if `TRUE`, return logical vector with x-y pair-wise predicate values

`prepared` logical; prepare geometry for `x`, before looping over `y`? See Details.

`model` character; polygon/polyline model; one of "open", "semi-open" or "closed"; see Details.

`retain_unique` logical; if `TRUE` (and `y` is missing) return only indexes of points larger than the current index; this can be used to select unique geometries, see examples. This argument can be used for all geometry predicates; see also distinct.sf to find records where geometries AND attributes are distinct.

`remove_self` logical; if `TRUE` (and `y` is missing) return only indexes of geometries different from the current index; this can be used to omit self-intersections; see examples. This argument can be used for all geometry predicates

`par` numeric; parameter used for "equals_exact" (margin);

`dist` distance threshold; geometry indexes with distances smaller or equal to this value are returned; numeric value or units value having distance units.

Details

If `prepared` is `TRUE`, and `x` contains POINT geometries and `y` contains polygons, then the polygon geometries are prepared, rather than the points.

For most predicates, a spatial index is built on argument `x`; see https://r-spatial.org/r/2017/06/22/spatial-index.html. Specifically, `st_intersects`, `st_disjoint`, `st_touches` `st_crosses`, `st_within`, `st_contains`, `st_contains_properly`, `st_overlaps`, `st_equals`, `st_covers` and `st_covered_by` all build spatial indexes for more efficient geometry calculations. `st_relate`, `st_equals_exact`, and do not; `st_is_within_distance` uses a spatial index for geographic coordinates when `sf_use_s2()` is true.

If `y` is missing, `st_predicate(x, x)` is effectively called, and a square matrix is returned with diagonal elements `st_predicate(x[i], x[i])`.

Sparse geometry binary predicate (sgbp) lists have the following attributes: `region.id` with the `row.names` of `x` (if any, else `1:n`), `ncol` with the number of features in `y`, and `predicate` with the name of the predicate used.

for `model`, see https://github.com/r-spatial/s2/issues/32

`st_contains_properly(A,B)` is true if A intersects B's interior, but not its edges or exterior; A contains A, but A does not properly contain A.

See also st_relate and https://en.wikipedia.org/wiki/DE-9IM for a more detailed description of the underlying algorithms.

`st_equals_exact` returns true for two geometries of the same type and their vertices corresponding by index are equal up to a specified tolerance.

Value

If sparse=FALSE, st_predicate (with predicate e.g. "intersects") returns a dense logical matrix with element i,j equal to TRUE when predicate(x[i], y[j]) (e.g., when geometry of feature i and j intersect); if sparse=TRUE, an object of class sgbp is returned, which is a sparse list representation of the same matrix, with list element i an integer vector with all indices j for which predicate(x[i],y[j]) is TRUE (and hence a zero-length integer vector if none of them is TRUE). From the dense matrix, one can find out if one or more elements intersect by apply(mat, 1, any), and from the sparse list by lengths(lst) > 0, see examples below. If by_element=TRUE, return a vector of pair-wise predicate values.

Note

For intersection on pairs of simple feature geometries, use the function st_intersection instead of st_intersects.

Examples

```
pts = st_sfc(st_point(c(.5,.5)), st_point(c(1.5, 1.5)), st_point(c(2.5, 2.5)))
pol = st_polygon(list(rbind(c(0,0), c(2,0), c(2,2), c(0,2), c(0,0))))
(lst = st_intersects(pts, pol))
(mat = st_intersects(pts, pol, sparse = FALSE))
# which points fall inside a polygon?
apply(mat, 1, any)
lengths(lst) > 0
# which points fall inside the first polygon?
st_intersects(pol, pts)[[1]]
# remove duplicate geometries:
p1 = st_point(0:1)
p2 = st_point(2:1)
p = st_sf(a = letters[1:8], geom = st_sfc(p1, p1, p2, p1, p1, p2, p2, p1))
st_equals(p)
st_equals(p, remove_self = TRUE)
(u = st_equals(p, retain_unique = TRUE))
# retain the records with unique geometries:
p[-unlist(u),]
```

---

geos_combine *Combine or union feature geometries*

Description

Combine several feature geometries into one, without unioning or resolving internal boundaries

Usage

```
st_combine(x)

st_union(x, y, ..., by_feature = FALSE, is_coverage = FALSE)
```

Arguments

x	object of class sf, sfc or sfg
y	object of class sf, sfc or sfg (optional)
...	ignored
by_feature	logical; if TRUE, union each feature if y is missing or else each pair of features; if FALSE return a single feature that is the geometric union of the set of features in x if y is missing, or else the unions of each of the elements of the Cartesian product of both sets
is_coverage	logical; if TRUE, use an optimized algorithm for features that form a polygonal coverage (have no overlaps)

Details

st_combine combines geometries without resolving borders, using c.sfg (analogous to c for ordinary vectors).

If st_union is called with a single argument, x, (with y missing) and by_feature is FALSE all geometries are unioned together and an sfg or single-geometry sfc object is returned. If by_feature is TRUE each feature geometry is unioned individually. This can for instance be used to resolve internal boundaries after polygons were combined using st_combine. If y is provided, all elements of x and y are unioned, pairwise if by_feature is TRUE, or else as the Cartesian product of both sets.

Unioning a set of overlapping polygons has the effect of merging the areas (i.e. the same effect as iteratively unioning all individual polygons together). Unioning a set of LineStrings has the effect of fully noding and dissolving the input linework. In this context "fully noded" means that there will be a node or endpoint in the output for every endpoint or line segment crossing in the input. "Dissolved" means that any duplicate (e.g. coincident) line segments or portions of line segments will be reduced to a single line segment in the output. Unioning a set of Points has the effect of merging all identical points (producing a set with no duplicates).

Value

st_combine returns a single, combined geometry, with no resolved boundaries; returned geometries may well be invalid.

If y is missing, st_union(x) returns a single geometry with resolved boundaries, else the geometries for all unioned pairs of x[i] and y[j].

See Also

st_intersection, st_difference, st_sym_difference

Examples

```
nc = st_read(system.file("shape/nc.shp", package="sf"))
st_combine(nc)
plot(st_union(nc))
```

geos_measures *Compute geometric measurements*

Description

Compute Euclidean or great circle distance between pairs of geometries; compute, the area or the length of a set of geometries.

Usage

```
st_area(x, ...)

## S3 method for class 'sfc'
st_area(x, ...)

st_length(x, ...)

st_perimeter(x, ...)

st_distance(
  x,
  y,
  ...,
  dist_fun,
  by_element = FALSE,
  which = ifelse(isTRUE(st_is_longlat(x)), "Great Circle", "Euclidean"),
  par = 0,
  tolerance = 0
)
```

Arguments

x	object of class sf, sfc or sfg
...	passed on to s2_distance, s2_distance_matrix, or s2_perimeter
y	object of class sf, sfc or sfg, defaults to x
dist_fun	deprecated
by_element	logical; if TRUE, return a vector with distance between the first elements of x and y, the second, etc; an error is raised if x and y are not the same length. If FALSE, return the dense matrix with all pairwise distances.
which	character; for Cartesian coordinates only: one of Euclidean, Hausdorff or Frechet; for geodetic coordinates, great circle distances are computed; see details
par	for which equal to Hausdorff or Frechet, optionally use a value between 0 and 1 to densify the geometry

tolerance — ignored if st_is_longlat(x) is FALSE; otherwise, if set to a positive value, the first distance smaller than tolerance will be returned, and true distance may be smaller; this may speed up computation. In meters, or a units object convertible to meters.

Details

great circle distance calculations use by default spherical distances (s2_distance or s2_distance_matrix); if sf_use_s2() is FALSE, ellipsoidal distances are computed using st_geod_distance which uses function geod_inverse from GeographicLib (part of PROJ); see Karney, Charles FF, 2013, Algorithms for geodesics, Journal of Geodesy 87(1), 43–55

Value

If the coordinate reference system of x was set, these functions return values with unit of measurement; see set_units.

st_area returns the area of each feature geometry, computed in the coordinate reference system used. In case x has geodetic coordinates (unprojected), then if sf_use_s2() is FALSE st_geod_area is used for area calculation, if it is TRUE then s2_area is used: the former assumes an ellipsoidal shape, the latter a spherical shape of the Earth. In case of projected data, areas are computed in flat space. The argument ... can be used to specify radius to s2_area, to modify the Earth radius.

st_length returns the length of a LINESTRING or MULTILINESTRING geometry, using the coordinate reference system. POINT, MULTIPOINT, POLYGON or MULTIPOLYGON geometries return zero. If coordinates are geodetic (i.e., long/lat), great circle calculations are carried out on a sphere (if sf_use_s2() is TRUE), or a geodesic line is computed on an ellipsoid (if sf_use_s2() is FALSE). For all other non-geodetic, projected coordinate systems, length calculations are planar, Euclidean distance calculations in the units of the coordinate system.

If by_element is FALSE st_distance returns a dense numeric matrix of dimension length(x) by length(y); otherwise it returns a numeric vector the same length as x and y with an error raised if the lengths of x and y are unequal. Distances involving empty geometries are NA.

See Also

st_dimension, st_cast to convert geometry types

Examples

```
b0 = st_polygon(list(rbind(c(-1,-1), c(1,-1), c(1,1), c(-1,1), c(-1,-1))))
b1 = b0 + 2
b2 = b0 + c(-0.2, 2)
x = st_sfc(b0, b1, b2)
st_area(x)
line = st_sfc(st_linestring(rbind(c(30,30), c(40,40))), crs = 4326)
st_length(line)

outer = matrix(c(0,0,10,0,10,10,0,10,0,0),ncol=2, byrow=TRUE)
hole1 = matrix(c(1,1,1,2,2,2,2,1,1,1),ncol=2, byrow=TRUE)
hole2 = matrix(c(5,5,5,6,6,6,6,5,5,5),ncol=2, byrow=TRUE)
```

```
poly = st_polygon(list(outer, hole1, hole2))
mpoly = st_multipolygon(list(
 list(outer, hole1, hole2),
 list(outer + 12, hole1 + 12)
))

st_length(st_sfc(poly, mpoly))
if (requireNamespace("lwgeom", quietly = TRUE)) {
  st_perimeter(poly)
  st_perimeter(mpoly)
}
p = st_sfc(st_point(c(0,0)), st_point(c(0,1)), st_point(c(0,2)))
st_distance(p, p)
st_distance(p, p, by_element = TRUE)
```

`geos_query` *Dimension, simplicity, validity or is_empty queries on simple feature geometries*

Description

Dimension, simplicity, validity or is_empty queries on simple feature geometries

Usage

```
st_dimension(x, NA_if_empty = TRUE)

st_is_simple(x)

st_is_empty(x)
```

Arguments

`x`	object of class `sf`, `sfc` or `sfg`
`NA_if_empty`	logical; if TRUE, return NA for empty geometries

Value

st_dimension returns a numeric vector with 0 for points, 1 for lines, 2 for surfaces, and, if `NA_if_empty` is `TRUE`, `NA` for empty geometries.

st_is_simple returns a logical vector, indicating for each geometry whether it is simple (e.g., not self-intersecting)

st_is_empty returns for each geometry whether it is empty

Examples

```
x = st_sfc(
 st_point(0:1),
 st_linestring(rbind(c(0,0),c(1,1))),
 st_polygon(list(rbind(c(0,0),c(1,0),c(0,1),c(0,0)))),
 st_multipoint(),
 st_linestring(),
 st_geometrycollection())
st_dimension(x)
st_dimension(x, FALSE)
ls = st_linestring(rbind(c(0,0), c(1,1), c(1,0), c(0,1)))
st_is_simple(st_sfc(ls, st_point(c(0,0))))
ls = st_linestring(rbind(c(0,0), c(1,1), c(1,0), c(0,1)))
st_is_empty(st_sfc(ls, st_point(), st_linestring()))
```

---

geos_unary *Geometric unary operations on simple feature geometry sets*

Description

Geometric unary operations on simple feature geometries. These are all generics, with methods for `sfg`, `sfc` and `sf` objects, returning an object of the same class. All operations work on a per-feature basis, ignoring all other features.

Usage

```
st_buffer(
  x,
  dist,
  nQuadSegs = 30,
  endCapStyle = "ROUND",
  joinStyle = "ROUND",
  mitreLimit = 1,
  singleSide = FALSE,
  ...
)

st_boundary(x)

st_convex_hull(x)

st_concave_hull(x, ratio, ..., allow_holes)

st_simplify(x, preserveTopology, dTolerance = 0)

st_triangulate(x, dTolerance = 0, bOnlyEdges = FALSE)
```

```
st_triangulate_constrained(x)

st_inscribed_circle(x, dTolerance, ...)

st_minimum_rotated_rectangle(x, ...)

st_minimum_bounding_circle(x, ...)

st_voronoi(
  x,
  envelope,
  dTolerance = 0,
  bOnlyEdges = FALSE,
  point_order = FALSE
)

st_polygonize(x)

st_line_merge(x, ..., directed = FALSE)

st_centroid(x, ..., of_largest_polygon = FALSE)

st_point_on_surface(x)

st_reverse(x)

st_node(x)

st_segmentize(x, dfMaxLength, ...)

st_exterior_ring(x, ...)
```

Arguments

x	object of class sfg, sfc or sf
dist	numeric or object of class units; buffer distance(s) for all, or for each of the elements in x. In case x has geodetic coordinates (lon/lat) and sf_use_s2() is TRUE, a numeric dist is taken as distance in meters and a units object in dist is converted to meters. In case x has geodetic coordinates (lon/lat) and sf_use_s2() is FALSE, a numeric dist is taken as degrees, and a units object in dist is converted to arc_degree (and warnings are issued). In case x does not have geodetic coordinates (projected) then numeric dist is assumed to have the units of the coordinates, and a units dist is converted to those if st_crs(x) is not NA.
nQuadSegs	integer; number of segments per quadrant (fourth of a circle), for all or per-feature; see details
endCapStyle	character; style of line ends, one of 'ROUND', 'FLAT', 'SQUARE'; see details
joinStyle	character; style of line joins, one of 'ROUND', 'MITRE', 'BEVEL'; see details

mitreLimit — numeric; limit of extension for a join if joinStyle 'MITRE' is used (default 1.0, minimum 0.0); see details

singleSide — logical; if TRUE, single-sided buffers are returned for linear geometries, in which case negative dist values give buffers on the right-hand side, positive on the left; see details

... — in st_buffer passed on to s2::s2_buffer_cells(), otherwise ignored

ratio — numeric; fraction convex: 1 returns the convex hulls, 0 maximally concave hulls

allow_holes — logical; if TRUE, the resulting concave hull may have holes

preserveTopology — logical; carry out topology preserving simplification? May be specified for each, or for all feature geometries. Note that topology is preserved only for single feature geometries, not for sets of them. If not specified (i.e. the default), then it is internally set equal to FALSE when the input data is specified with projected coordinates or sf_use_s2() returns FALSE. Ignored in all the other cases (with a warning when set equal to FALSE) since the function implicitly calls s2::s2_simplify which always preserve topological relationships (per single feature).

dTolerance — numeric; tolerance parameter, specified for all or for each feature geometry. If you run st_simplify, the input data is specified with long-lat coordinates and sf_use_s2() returns TRUE, then the value of dTolerance must be specified in meters.

bOnlyEdges — logical; if TRUE, return lines, else return polygons

envelope — object of class sfc or sfg containing a POLYGON with the envelope for a voronoi diagram; this only takes effect when it is larger than the default envelope, chosen when envelope is an empty polygon

point_order — logical; preserve point order if TRUE and GEOS version >= 3.12; overrides bOnlyEdges

directed — logical; if TRUE, lines with opposite directions will not be merged

of_largest_polygon — logical; for st_centroid: if TRUE, return centroid of the largest (sub)polygon of a MULTIPOLYGON rather than of the whole MULTIPOLYGON

dfMaxLength — maximum length of a line segment. If x has geographical coordinates (long/lat), dfMaxLength is either a numeric expressed in meter, or an object of class units with length units rad or degree; segmentation in the long/lat case takes place along the great circle, using st_geod_segmentize.

Details

st_buffer computes a buffer around this geometry/each geometry. Depending on the spatial coordinate system, a different engine (GEOS or S2) can be used, which have different function arguments. The nQuadSegs, endCapsStyle, joinStyle, mitreLimit and singleSide parameters only work if the GEOS engine is used (i.e. projected coordinates or when sf_use_s2() is set to FALSE). See postgis.net/docs/ST_Buffer.html for details. The max_cells and min_level parameters (s2::s2_buffer_cells()) work with the S2 engine (i.e. geographic coordinates) and can be used to change the buffer shape (e.g. smoothing). The S2 engine returns a polygon *around* a

number of S2 cells that contain the buffer, and hence will always have an area larger than the true buffer, depending on `max_cells`, and will be non-smooth when sufficiently zoomed in. The GEOS engine will return line segments between points on the circle, and so will always be *smaller* than the true buffer, and be smooth, depending on the number of segments `nQuadSegs`. A negative `dist` value for geodetic coordinates using S2 does not give a proper (geodetic) buffer.

`st_boundary` returns the boundary of a geometry

`st_convex_hull` creates the convex hull of a set of points

`st_concave_hull` creates the concave hull of a geometry

`st_simplify` simplifies lines by removing vertices.

`st_triangulate` triangulates set of points (not constrained). `st_triangulate` requires GEOS version 3.4 or above

`st_triangulate_constrained` returns the constrained delaunay triangulation of polygons; requires GEOS version 3.10 or above

`st_inscribed_circle` returns the maximum inscribed circle for polygon geometries. For `st_inscribed_circle`, if `nQuadSegs` is 0 a 2-point LINESTRING is returned with the center point and a boundary point of every circle, otherwise a circle (buffer) is returned where `nQuadSegs` controls the number of points per quadrant to approximate the circle. `st_inscribed_circle` requires GEOS version 3.9 or above

`st_minimum_rotated_rectangle` returns the minimum rotated rectangular POLYGON which encloses the input geometry. The rectangle has width equal to the minimum diameter, and a longer length. If the convex hill of the input is degenerate (a line or point) a linestring or point is returned.

`st_minimum_bounding_circle` returns a geometry which represents the "minimum bounding circle", the smallest circle that contains the input.

`st_voronoi` creates voronoi tessellation. `st_voronoi` requires GEOS version 3.5 or above

`st_polygonize` creates a polygon from lines that form a closed ring. In case of `st_polygonize`, `x` must be an object of class `LINESTRING` or `MULTILINESTRING`, or an `sfc` geometry list-column object containing these

`st_line_merge` merges lines. In case of `st_line_merge`, `x` must be an object of class `MULTILINESTRING`, or an `sfc` geometry list-column object containing these

`st_centroid` gives the centroid of a geometry

`st_point_on_surface` returns a point guaranteed to be on the (multi)surface.

`st_reverse` reverses the nodes in a line

`st_node` adds nodes to linear geometries at intersections without a node, and only works on individual linear geometries

`st_segmentize` adds points to straight lines

`st_exterior_ring` returns the exterior rings of polygons, removing all holes.

Value

an object of the same class of `x`, with manipulated geometry.

See Also

chull for a more efficient algorithm for calculating the convex hull

Examples

```
## st_buffer, style options (taken from rgeos gBuffer)
l1 = st_as_sfc("LINESTRING(0 0,1 5,4 5,5 2,8 2,9 4,4 6.5)")
op = par(mfrow=c(2,3))
plot(st_buffer(l1, dist = 1, endCapStyle="ROUND"), reset = FALSE, main = "endCapStyle: ROUND")
plot(l1,col='blue',add=TRUE)
plot(st_buffer(l1, dist = 1, endCapStyle="FLAT"), reset = FALSE, main = "endCapStyle: FLAT")
plot(l1,col='blue',add=TRUE)
plot(st_buffer(l1, dist = 1, endCapStyle="SQUARE"), reset = FALSE, main = "endCapStyle: SQUARE")
plot(l1,col='blue',add=TRUE)
plot(st_buffer(l1, dist = 1, nQuadSegs=1), reset = FALSE, main = "nQuadSegs: 1")
plot(l1,col='blue',add=TRUE)
plot(st_buffer(l1, dist = 1, nQuadSegs=2), reset = FALSE, main = "nQuadSegs: 2")
plot(l1,col='blue',add=TRUE)
plot(st_buffer(l1, dist = 1, nQuadSegs= 5), reset = FALSE, main = "nQuadSegs: 5")
plot(l1,col='blue',add=TRUE)
par(op)


l2 = st_as_sfc("LINESTRING(0 0,1 5,3 2)")
op = par(mfrow = c(2, 3))
plot(st_buffer(l2, dist = 1, joinStyle="ROUND"), reset = FALSE, main = "joinStyle: ROUND")
plot(l2, col = 'blue', add = TRUE)
plot(st_buffer(l2, dist = 1, joinStyle="MITRE"), reset = FALSE, main = "joinStyle: MITRE")
plot(l2, col= 'blue', add = TRUE)
plot(st_buffer(l2, dist = 1, joinStyle="BEVEL"), reset = FALSE, main = "joinStyle: BEVEL")
plot(l2, col= 'blue', add=TRUE)
plot(st_buffer(l2, dist = 1, joinStyle="MITRE" , mitreLimit=0.5), reset = FALSE,
   main = "mitreLimit: 0.5")
plot(l2, col = 'blue', add = TRUE)
plot(st_buffer(l2, dist = 1, joinStyle="MITRE",mitreLimit=1), reset = FALSE,
   main = "mitreLimit: 1")
plot(l2, col = 'blue', add = TRUE)
plot(st_buffer(l2, dist = 1, joinStyle="MITRE",mitreLimit=3), reset = FALSE,
   main = "mitreLimit: 3")
plot(l2, col = 'blue', add = TRUE)
par(op)

# compare approximation errors depending on S2 or GEOS backend:
# geographic coordinates, uses S2:
x = st_buffer(st_as_sf(data.frame(lon=0,lat=0), coords=c("lon","lat"),crs='OGC:CRS84'),
      units::as_units(1,"km"))
y = units::set_units(st_area(x), "km^2")
# error: postive, default maxcells = 1000
(units::drop_units(y)-pi)/pi
x = st_buffer(st_as_sf(data.frame(lon=0,lat=0), coords=c("lon","lat"),crs='OGC:CRS84'),
      units::as_units(1,"km"), max_cells=1e5)
y = units::set_units(st_area(x), "km^2")
# error: positive but smaller:
(units::drop_units(y)-pi)/pi

# no CRS set: assumes Cartesian (projected) coordinates
```

```
x = st_buffer(st_as_sf(data.frame(lon=0,lat=0), coords=c("lon","lat")), 1)
y = st_area(x)
# error: negative, nQuadSegs default at 30
((y)-pi)/pi
x = st_buffer(st_as_sf(data.frame(lon=0,lat=0), coords=c("lon","lat")), 1, nQuadSegs = 100)
y = st_area(x)
# error: negative but smaller:
((y)-pi)/pi
nc = st_read(system.file("shape/nc.shp", package="sf"))
nc_g = st_geometry(nc)
plot(st_convex_hull(nc_g))
plot(nc_g, border = grey(.5), add = TRUE)
pt = st_combine(st_sfc(st_point(c(0,80)), st_point(c(120,80)), st_point(c(240,80))))
st_convex_hull(pt) # R2
st_convex_hull(st_set_crs(pt, 'OGC:CRS84')) # S2
set.seed(131)
if (compareVersion(sf_extSoftVersion()[["GEOS"]], "3.11.0") > -1) {
 pts = cbind(runif(100), runif(100))
 m = st_multipoint(pts)
 co = sf:::st_concave_hull(m, 0.3)
 coh = sf:::st_concave_hull(m, 0.3, allow_holes = TRUE)
 plot(co, col = 'grey')
 plot(coh, add = TRUE, border = 'red')
 plot(m, add = TRUE)
}

# st_simplify examples:
op = par(mfrow = c(2, 3), mar = rep(0, 4))
plot(nc_g[1])
plot(st_simplify(nc_g[1], dTolerance = 1e3)) # 1000m
plot(st_simplify(nc_g[1], dTolerance = 5e3)) # 5000m
nc_g_planar = st_transform(nc_g, 2264) # planar coordinates, US foot
plot(nc_g_planar[1])
plot(st_simplify(nc_g_planar[1], dTolerance = 1e3)) # 1000 foot
plot(st_simplify(nc_g_planar[1], dTolerance = 5e3)) # 5000 foot
par(op)

if (compareVersion(sf_extSoftVersion()[["GEOS"]], "3.10.0") > -1) {
 pts = rbind(c(0,0), c(1,0), c(1,1), c(.5,.5), c(0,1), c(0,0))
 po = st_polygon(list(pts))
 co = st_triangulate_constrained(po)
 tr = st_triangulate(po)
 plot(po, col = NA, border = 'grey', lwd = 15)
 plot(tr, border = 'green', col = NA, lwd = 5, add = TRUE)
 plot(co, border = 'red', col = 'NA', add = TRUE)
}
if (compareVersion(sf_extSoftVersion()[["GEOS"]], "3.9.0") > -1) {
  nc_t = st_transform(nc, 'EPSG:2264')
  x = st_inscribed_circle(st_geometry(nc_t))
  plot(st_geometry(nc_t), asp = 1, col = grey(.9))
  plot(x, add = TRUE, col = '#ff9999')
}
set.seed(1)
```

```
x = st_multipoint(matrix(runif(10),,2))
box = st_polygon(list(rbind(c(0,0),c(1,0),c(1,1),c(0,1),c(0,0))))
if (compareVersion(sf_extSoftVersion()[["GEOS"]], "3.5.0") > -1) {
 v = st_sfc(st_voronoi(x, st_sfc(box)))
 plot(v, col = 0, border = 1, axes = TRUE)
 plot(box, add = TRUE, col = 0, border = 1) # a larger box is returned, as documented
 plot(x, add = TRUE, col = 'red', cex=2, pch=16)
 plot(st_intersection(st_cast(v), box)) # clip to smaller box
 plot(x, add = TRUE, col = 'red', cex=2, pch=16)
 # matching Voronoi polygons to data points:
 # https://github.com/r-spatial/sf/issues/1030
 # generate 50 random unif points:
 n = 100
 pts = st_as_sf(data.frame(matrix(runif(n), , 2), id = 1:(n/2)), coords = c("X1", "X2"))
 # compute Voronoi polygons:
 pols = st_collection_extract(st_voronoi(do.call(c, st_geometry(pts))))
 # match them to points:
 pts_pol = st_intersects(pts, pols)
 pts$pols = pols[unlist(pts_pol)] # re-order
 if (isTRUE(try(compareVersion(sf_extSoftVersion()["GEOS"], "3.12.0") > -1,
   silent = TRUE))) {
   pols_po = st_collection_extract(st_voronoi(do.call(c, st_geometry(pts)),
     point_order = TRUE)) # GEOS >= 3.12 can preserve order of inputs
   pts_pol_po = st_intersects(pts, pols_po)
   print(all(unlist(pts_pol_po) == 1:(n/2)))
 }
 plot(pts["id"], pch = 16) # ID is color
 plot(st_set_geometry(pts, "pols")["id"], xlim = c(0,1), ylim = c(0,1), reset = FALSE)
 plot(st_geometry(pts), add = TRUE)
 layout(matrix(1)) # reset plot layout
}
mls = st_multilinestring(list(matrix(c(0,0,0,1,1,1,0,0),,2,byrow=TRUE)))
st_polygonize(st_sfc(mls))
mls = st_multilinestring(list(rbind(c(0,0), c(1,1)), rbind(c(2,0), c(1,1))))
st_line_merge(st_sfc(mls))
plot(nc_g, axes = TRUE)
plot(st_centroid(nc_g), add = TRUE, pch = 3, col = 'red')
mp = st_combine(st_buffer(st_sfc(lapply(1:3, function(x) st_point(c(x,x)))), 0.2 * 1:3))
plot(mp)
plot(st_centroid(mp), add = TRUE, col = 'red') # centroid of combined geometry
plot(st_centroid(mp, of_largest_polygon = TRUE), add = TRUE, col = 'blue', pch = 3)
plot(nc_g, axes = TRUE)
plot(st_point_on_surface(nc_g), add = TRUE, pch = 3, col = 'red')
if (compareVersion(sf_extSoftVersion()[["GEOS"]], "3.7.0") > -1) {
  st_reverse(st_linestring(rbind(c(1,1), c(2,2), c(3,3))))
}
(l = st_linestring(rbind(c(0,0), c(1,1), c(0,1), c(1,0), c(0,0))))
st_polygonize(st_node(l))
st_node(st_multilinestring(list(rbind(c(0,0), c(1,1), c(0,1), c(1,0), c(0,0)))))
sf = st_sf(a=1, geom=st_sfc(st_linestring(rbind(c(0,0),c(1,1)))), crs = 4326)
if (require(lwgeom, quietly = TRUE)) {
 seg = st_segmentize(sf, units::set_units(100, km))
 seg = st_segmentize(sf, units::set_units(0.01, rad))
```

```
 nrow(seg$geom[[1]])
}
```

`interpolate_aw` *Area-weighted interpolation or dasymetric mapping of polygon data*

Description

Area-weighted interpolation or dasymetric mapping of polygon data

Usage

```
st_interpolate_aw(x, to, extensive, ...)

## S3 method for class 'sf'
st_interpolate_aw(
  x,
  to,
  extensive,
  ...,
  keep_NA = FALSE,
  na.rm = FALSE,
  include_non_intersected = FALSE,
  weights = character(0)
)
```

Arguments

`x`	object of class `sf`, for which we want to aggregate attributes
`to`	object of class `sf` or `sfc`, with the target geometries
`extensive`	logical; if TRUE, the attribute variables are assumed to be spatially extensive (like population) and the sum is preserved, otherwise, spatially intensive (like population density) and the mean is preserved.
`...`	ignored
`keep_NA`	logical; if `TRUE`, return all features in `to`, if `FALSE` return only those with non-NA values (but with `row.names` the index corresponding to the feature in `to`)
`na.rm`	logical; if `TRUE` remove features with `NA` attributes from `x` before interpolating
`include_non_intersected`	logical; for the case when `extensive=FALSE`, when set to `TRUE` divide by the target areas (including non-intersected areas), when `FALSE` divide by the sum of the source areas.
`weights`	character; name of column in `to` that indicates (extensive) weights, to be used instead of areas, for redistributing attributes in `x`; currently only works for `extensive=TRUE`.

Details

if `extensive` is `TRUE` and `na.rm` is set to `TRUE`, geometries with `NA` are effectively treated as having zero attribute values. Dasymetric mapping is obtained when `weights` are specified.

Examples

```
# example Area-weighted interpolation:
nc = st_read(system.file("shape/nc.shp", package="sf"))
g = st_make_grid(nc, n = c(10, 5))
a1 = st_interpolate_aw(nc["BIR74"], g, extensive = FALSE)
sum(a1$BIR74) / sum(nc$BIR74) # not close to one: property is assumed spatially intensive
a2 = st_interpolate_aw(nc["BIR74"], g, extensive = TRUE)
# verify mass preservation (pycnophylactic) property:
sum(a2$BIR74) / sum(nc$BIR74)
a1$intensive = a1$BIR74
a1$extensive = a2$BIR74
plot(a1[c("intensive", "extensive")], key.pos = 4)

# example Dasymetric mapping:
# load nr of addresses per 10 km grid cell, to proxy population -> birth density:
grd.addr = system.file("gpkg/grd_addr.gpkg", package="sf") |> read_sf()
xgrd.addr = grd.addr # copy for plotting
xgrd.addr$ones[grd.addr$ones==0] = 1 # so that logz shows finite values
plot(xgrd.addr, logz=TRUE, main = "nr of addresses per cell") # log scale
nc = st_transform(nc, st_crs(grd.addr))
# avoid "assumes attributes are constant or uniform over areas" warnings:
st_agr(nc) = c(BIR74 = "constant", BIR79 = "constant")
st_agr(grd.addr) = c(ones = "constant")
# dasymetric mapping
bir.grd = st_interpolate_aw(nc[c("BIR74","BIR79")], extensive = TRUE, grd.addr, weights = "ones")
xbir.grd = bir.grd # copy for plotting
xbir.grd$BIR74[xbir.grd$BIR74 == 0] = 1 # so that logz shows finite values
plot(xbir.grd["BIR74"], logz = TRUE, main = "redistributed birth counts, 1974-")
# verify sums:
apply(as.data.frame(bir.grd)[1:2], 2, sum)
apply(as.data.frame(nc)[c("BIR74", "BIR79")], 2, sum)
# compare county-wise:
st_agr(bir.grd) = c(BIR74 = "constant")
aw = st_interpolate_aw(bir.grd["BIR74"], st_geometry(nc), extensive = TRUE)
plot(nc$BIR74, aw$BIR74, log = 'xy', xlab = 'county-value', ylab = 'area-w interpolated')
abline(0,1)
```

---

is_driver_available *Check if driver is available*

Description

Search through the driver table if driver is listed

Usage

```
is_driver_available(drv, drivers = st_drivers())
```

Arguments

drv	character. Name of driver
drivers	data.frame. Table containing driver names and support. Default is from st_drivers

---

is_driver_can *Check if a driver can perform an action*

Description

Search through the driver table to match a driver name with an action (e.g. "write") and check if the action is supported.

Usage

```
is_driver_can(drv, drivers = st_drivers(), operation = "write")
```

Arguments

drv	character. Name of driver
drivers	data.frame. Table containing driver names and support. Default is from st_drivers
operation	character. What action to check

---

is_geometry_column *Check if the columns could be of a coercable type for sf*

Description

Check if the columns could be of a coercable type for sf

Usage

```
is_geometry_column(con, x, classes = "")
```

Arguments

con	database connection
x	inherits data.frame
classes	classes inherited

merge.sf *merge method for sf and data.frame object*

Description

merge method for sf and data.frame object

Usage

```
## S3 method for class 'sf'
merge(x, y, ...)
```

Arguments

x	object of class sf
y	object of class data.frame
...	arguments passed on to merge.data.frame

Examples

```
a = data.frame(a = 1:3, b = 5:7)
st_geometry(a) = st_sfc(st_point(c(0,0)), st_point(c(1,1)), st_point(c(2,2)))
b = data.frame(x = c("a", "b", "c"), b = c(2,5,6))
merge(a, b)
merge(a, b, all = TRUE)
```

nc *North Carolina SIDS data*

Description

Sudden Infant Death Syndrome (SIDS) sample data for North Carolina counties, two time periods (1974-78 and 1979-84). The details of the columns can be found in a spdep package vignette. Please note that, though this is basically the same as nc.sids dataset in spData package, nc only contains a subset of variables. The differences are also discussed on the vignette.

Format

A sf object

See Also

https://r-spatial.github.io/spdep/articles/sids.html

Examples

```
nc <- st_read(system.file("shape/nc.shp", package="sf"))
```

Ops *Arithmetic operators for simple feature geometries*

Description

Arithmetic operators for simple feature geometries

Usage

```
## S3 method for class 'sfg'
Ops(e1, e2)

## S3 method for class 'sfc'
Ops(e1, e2)
```

Arguments

e1	object of class sfg or sfc
e2	numeric, or object of class sfg; in case e1 is of class sfc also an object of class sfc is allowed

Details

in case e2 is numeric, +, -, *, /, %% and %/% add, subtract, multiply, divide, modulo, or integer-divide by e2. In case e2 is an n x n matrix, * matrix-multiplies and / multiplies by its inverse. If e2 is an sfg object, |, /, & and %/% result in the geometric union, difference, intersection and symmetric difference respectively, and == and != return geometric (in)equality, using st_equals. If e2 is an sfg or sfc object, for operations + and - it has to have POINT geometries.

If e1 is of class sfc, and e2 is a length 2 numeric, then it is considered a two-dimensional point (and if needed repeated as such) only for operations + and -, in other cases the individual numbers are repeated; see commented examples.

It has been reported (https://github.com/r-spatial/sf/issues/2067) that certain ATLAS versions result in invalid polygons, where the final point in a ring is no longer equal to the first point. In that case, setting the precisions with st_set_precision may help.

Value

object of class sfg

Examples

```
st_point(c(1,2,3)) + 4
st_point(c(1,2,3)) * 3 + 4
m = matrix(0, 2, 2)
diag(m) = c(1, 3)
# affine:
st_point(c(1,2)) * m + c(2,5)
```

```
# world in 0-360 range:
if (require(maps, quietly = TRUE)) {
 w = st_as_sf(map('world', plot = FALSE, fill = TRUE))
 w2 = (st_geometry(w) + c(360,90)) %% c(360) - c(0,90)
 w3 = st_wrap_dateline(st_set_crs(w2 - c(180,0), 4326)) + c(180,0)
 plot(st_set_crs(w3, 4326), axes = TRUE)
}
(mp <- st_point(c(1,2)) + st_point(c(3,4))) # MULTIPOINT (1 2, 3 4)
mp - st_point(c(3,4)) # POINT (1 2)
opar = par(mfrow = c(2,2), mar = c(0, 0, 1, 0))
a = st_buffer(st_point(c(0,0)), 2)
b = a + c(2, 0)
p = function(m) { plot(c(a,b)); plot(eval(parse(text=m)), col=grey(.9), add = TRUE); title(m) }
o = lapply(c('a | b', 'a / b', 'a & b', 'a %/% b'), p)
par(opar)
sfc = st_sfc(st_point(0:1), st_point(2:3))
sfc + c(2,3) # added to EACH geometry
sfc * c(2,3) # first geometry multiplied by 2, second by 3
nc = st_transform(st_read(system.file("gpkg/nc.gpkg", package="sf")), 32119) # nc state plane, m
b = st_buffer(st_centroid(st_union(nc)), units::set_units(50, km)) # shoot a hole in nc:
plot(st_geometry(nc) / b, col = grey(.9))
```

---

plot *plot sf object*

Description

plot one or more attributes of an sf object on a map Plot sf object

Usage

```
## S3 method for class 'sf'
plot(
  x,
  y,
  ...,
  main,
  pal = NULL,
  nbreaks = 10,
  breaks = "pretty",
  max.plot = getOption("sf_max.plot", default = 9),
  key.pos = get_key_pos(x, ...),
  key.length = 0.618,
  key.width = kw_dflt(x, key.pos),
  reset = TRUE,
  logz = FALSE,
  extent = x,
  xlim = st_bbox(extent)[c(1, 3)],
  ylim = st_bbox(extent)[c(2, 4)],
```

```
  compact = FALSE
)

get_key_pos(x, ...)

## S3 method for class 'sfc_POINT'
plot(
  x,
  y,
  ...,
  pch = 1,
  cex = 1,
  col = 1,
  bg = 0,
  lwd = 1,
  lty = 1,
  type = "p",
  add = FALSE
)

## S3 method for class 'sfc_MULTIPOINT'
plot(
  x,
  y,
  ...,
  pch = 1,
  cex = 1,
  col = 1,
  bg = 0,
  lwd = 1,
  lty = 1,
  type = "p",
  add = FALSE
)

## S3 method for class 'sfc_LINESTRING'
plot(x, y, ..., lty = 1, lwd = 1, col = 1, pch = 1, type = "l", add = FALSE)

## S3 method for class 'sfc_CIRCULARSTRING'
plot(x, y, ...)

## S3 method for class 'sfc_MULTILINESTRING'
plot(x, y, ..., lty = 1, lwd = 1, col = 1, pch = 1, type = "l", add = FALSE)

## S3 method for class 'sfc_POLYGON'
plot(
  x,
  y,
```

```
  ...,
  lty = 1,
  lwd = 1,
  col = NA,
  cex = 1,
  pch = NA,
  border = 1,
  add = FALSE,
  rule = "evenodd",
  xpd = par("xpd")
)

## S3 method for class 'sfc_MULTIPOLYGON'
plot(
  x,
  y,
  ...,
  lty = 1,
  lwd = 1,
  col = NA,
  border = 1,
  add = FALSE,
  rule = "evenodd",
  xpd = par("xpd")
)

## S3 method for class 'sfc_GEOMETRYCOLLECTION'
plot(
  x,
  y,
  ...,
  pch = 1,
  cex = 1,
  bg = 0,
  lty = 1,
  lwd = 1,
  col = 1,
  border = 1,
  add = FALSE
)

## S3 method for class 'sfc_GEOMETRY'
plot(
  x,
  y,
  ...,
  pch = 1,
  cex = 1,
```

```
  bg = 0,
  lty = 1,
  lwd = 1,
  col = ifelse(st_dimension(x) == 2, NA, 1),
  border = 1,
  add = FALSE
)

## S3 method for class 'sfg'
plot(x, ...)

plot_sf(
  x,
  xlim = NULL,
  ylim = NULL,
  asp = NA,
  axes = FALSE,
  bgc = par("bg"),
  ...,
  xaxs,
  yaxs,
  lab,
  setParUsrBB = FALSE,
  bgMap = NULL,
  expandBB = c(0, 0, 0, 0),
  graticule = NA_crs_,
  col_graticule = "grey",
  border,
  extent = x
)

sf.colors(n = 10, cutoff.tails = c(0.35, 0.2), alpha = 1, categorical = FALSE)

## S3 method for class 'sf'
text(x, labels = row.names(x), ...)

## S3 method for class 'sfc'
text(x, labels = seq_along(x), ..., of_largest_polygon = FALSE)

## S3 method for class 'sf'
points(x, ...)

## S3 method for class 'sfc'
points(x, ..., of_largest_polygon = FALSE)
```

Arguments

x	object of class sf

y	ignored
...	further specifications, see plot_sf and plot and details.
main	title for plot (NULL to remove)
pal	palette function, similar to rainbow, or palette values; if omitted, sf.colors is used
nbreaks	number of colors breaks (ignored for factor or character variables)
breaks	either a numeric vector with the actual breaks, or a name of a method accepted by the style argument of classIntervals
max.plot	integer; lower boundary to maximum number of attributes to plot; the default value (9) can be overridden by setting the global option sf_max.plot, e.g. options(sf_max.plot=2)
key.pos	numeric; side to plot a color key: 1 bottom, 2 left, 3 top, 4 right; set to NULL to omit key completely, 0 to only not plot the key, or -1 to select automatically. If multiple columns are plotted in a single function call by default no key is plotted and every submap is stretched individually; if a key is requested (and col is missing) all maps are colored according to a single key. Auto select depends on plot size, map aspect, and, if set, parameter asp. If it has lenght 2, the second value, ranging from 0 to 1, determines where the key is placed in the available space (default: 0.5, center).
key.length	amount of space reserved for the key along its axis, length of the scale bar
key.width	amount of space reserved for the key (incl. labels), thickness/width of the scale bar
reset	logical; if FALSE, keep the plot in a mode that allows adding further map elements; if TRUE restore original mode after plotting sf objects with attributes; see details.
logz	logical; if TRUE, use log10-scale for the attribute variable. In that case, breaks and at need to be given as log10-values; see examples.
extent	object with an st_bbox method to define plot extent; defaults to x
xlim	see plot.window
ylim	see plot.window
compact	logical; compact sub-plots over plotting space?
pch	plotting symbol
cex	symbol size
col	color for plotting features; if length(col) does not equal 1 or nrow(x), a warning is emitted that colors will be recycled. Specifying col suppresses plotting the legend key.
bg	symbol background color
lwd	line width
lty	line type
type	plot type: 'p' for points, 'l' for lines, 'b' for both
add	logical; add to current plot? Note that when using add=TRUE, you may have to set reset=FALSE in the first plot command.

border	color of polygon border(s); using NA hides them
rule	see polypath; for winding, exterior ring direction should be opposite that of the holes; with evenodd, plotting is robust against misspecified ring directions
xpd	see par; sets polygon clipping strategy; only implemented for POLYGON and MULTIPOLYGON
asp	see below, and see par
axes	logical; should axes be plotted? (default FALSE)
bgc	background color
xaxs	see par
yaxs	see par
lab	see par
setParUsrBB	default FALSE; set the par "usr" bounding box; see below
bgMap	object of class ggmap, or returned by function RgoogleMaps::GetMap
expandBB	numeric; fractional values to expand the bounding box with, in each direction (bottom, left, top, right)
graticule	logical, or object of class crs (e.g., st_crs('OGC:CRS84') for a WGS84 graticule), or object created by st_graticule
col_graticule	color to used for the graticule (if present)
n	integer; number of colors
cutoff.tails	numeric, in [0,0.5] start and end values
alpha	numeric, in [0,1], transparency
categorical	logical; do we want colors for a categorical variable? (see details)
labels	character, text to draw (one per row of input)
of_largest_polygon	logical, passed on to st_centroid

Details

plot.sf maximally plots max.plot maps with colors following from attribute columns, one map per attribute. It uses sf.colors for default colors. For more control over placement of individual maps, set parameter mfrow with par prior to plotting, and plot single maps one by one; note that this only works in combination with setting parameters key.pos=NULL (no legend) and reset=FALSE.

plot.sfc plots the geometry, additional parameters can be passed on to control color, lines or symbols.

When setting reset to FALSE, the original device parameters are lost, and the device must be reset using dev.off() in order to reset it.

parameter at can be set to specify where labels are placed along the key; see examples.

parameter mar can be set in ... to override default margins.

The features are plotted in the order as they apppear in the sf object. See examples for when a different plotting order is wanted.

plot_sf sets up the plotting area, axes, graticule, or webmap background; it is called by all plot methods before anything is drawn.

The argument setParUsrBB may be used to pass the logical value TRUE to functions within plot.Spatial. When set to TRUE, par("usr") will be overwritten with c(xlim, ylim), which defaults to the bounding box of the spatial object. This is only needed in the particular context of graphic output to a specified device with given width and height, to be matched to the spatial object, when using par("xaxs") and par("yaxs") in addition to par(mar=c(0,0,0,0)).

The default aspect for map plots is 1; if however data are not projected (coordinates are long/lat), the aspect is by default set to 1/cos(My * pi/180) with My the y coordinate of the middle of the map (the mean of ylim, which defaults to the y range of bounding box). This implies an Equirectangular projection.

non-categorical colors from sf.colors were taken from bpy.colors, with modified cutoff.tails defaults If categorical is TRUE, default colors are from https://colorbrewer2.org/ (if n < 9, Set2, else Set3).

text.sf adds text to an existing base graphic. Text is placed at the centroid of each feature in x. Provide POINT features for further control of placement. points.sf adds point symbols to an existing base graphic. If points of text are not shown correctly, try setting argument reset to FALSE in the plot() call.

Examples

```
nc = st_read(system.file("gpkg/nc.gpkg", package="sf"), quiet = TRUE)
# plot single attribute, auto-legend:
plot(nc["SID74"])
# plot multiple:
plot(nc[c("SID74", "SID79")]) # better use ggplot2::geom_sf to facet and get a single legend!
# adding to a plot of an sf object only works when using reset=FALSE in the first plot:
plot(nc["SID74"], reset = FALSE)
plot(st_centroid(st_geometry(nc)), add = TRUE)
# log10 z-scale:
plot(nc["SID74"], logz = TRUE, breaks = c(0,.5,1,1.5,2), at = c(0,.5,1,1.5,2))
# and we need to reset the plotting device after that, e.g. by
layout(1)
# when plotting only geometries, the reset=FALSE is not needed:
plot(st_geometry(nc))
plot(st_geometry(nc)[1], col = 'red', add = TRUE)
# add a custom legend to an arbitray plot:
layout(matrix(1:2, ncol = 2), widths = c(1, lcm(2)))
plot(1)
.image_scale(1:10, col = sf.colors(9), key.length = lcm(8), key.pos = 4, at = 1:10)
# manipulate plotting order, plot largest polygons first:
p = st_polygon(list(rbind(c(0,0), c(1,0), c(1,1), c(0,1), c(0,0))))
x = st_sf(a=1:4, st_sfc(p, p * 2, p * 3, p * 4)) # plot(x, col=2:5) only shows the largest polygon!
plot(x[order(st_area(x), decreasing = TRUE),], col = 2:5) # plot largest polygons first

sf.colors(10)
text(nc, labels = substring(nc$NAME,1,1))
```

prefix_map *Map prefix to driver*

Description

Map prefix to driver

Usage

```
prefix_map
```

proj_tools *Manage PROJ settings*

Description

Query or manage PROJ search path and network settings

Usage

```
sf_proj_search_paths(paths = character(0), with_proj = NA)

sf_proj_network(enable = FALSE, url = character(0))

sf_proj_pipelines(
  source_crs,
  target_crs,
  authority = character(0),
  AOI = numeric(0),
  Use = "NONE",
  grid_availability = "USED",
  desired_accuracy = -1,
  strict_containment = FALSE,
  axis_order_authority_compliant = st_axis_order()
)
```

Arguments

paths	the search path to be set; omit if paths need to be queried
with_proj	logical; if NA set for both GDAL and PROJ, otherwise set either for PROJ (TRUE) or GDAL (FALSE)
enable	logical; set this to enable (TRUE) or disable (FALSE) the proj network search facility
url	character; use this to specify and override the default proj network CDN

source_crs, target_crs
: object of class crs or character

authority
: character; constrain output pipelines to those of authority

AOI
: length four numeric; desired area of interest for the resulting coordinate transformations (west, south, east, north, in degrees). For an area of interest crossing the anti-meridian, west will be greater than east.

Use
: one of "NONE", "BOTH", "INTERSECTION", "SMALLEST", indicating how AOI's of source_crs and target_crs are being used

grid_availability
: character; one of "USED" (Grid availability is only used for sorting results. Operations where some grids are missing will be sorted last), "DISCARD" (Completely discard an operation if a required grid is missing) , "IGNORED" (Ignore grid availability at all. Results will be presented as if all grids were available.), or "AVAILABLE" (Results will be presented as if grids known to PROJ (that is registered in the grid_alternatives table of its database) were available. Used typically when networking is enabled.)

desired_accuracy
: numeric; only return pipelines with at least this accuracy

strict_containment
: logical; default FALSE; permit partial matching of the area of interest; if TRUE strictly contain the area of interest. The area of interest is either as given in AOI, or as implied by the source/target coordinate reference systems

axis_order_authority_compliant
: logical; if FALSE always choose 'x' or longitude for the first axis; if TRUE, follow the axis orders given by the coordinate reference systems when constructing the for the first axis; if FALSE, follow the axis orders given by

Value

sf_proj_search_paths() returns the search path (possibly after setting it)

sf_proj_network when called without arguments returns a logical indicating whether network search of datum grids is enabled, when called with arguments it returns a character vector with the URL of the CDN used (or specified with url).

sf_proj_pipelines() returns a table with candidate coordinate transformation pipelines along with their accuracy; NA accuracy indicates ballpark accuracy.

---

rawToHex *Convert raw vector(s) into hexadecimal character string(s)*

Description

Convert raw vector(s) into hexadecimal character string(s)

Usage

```
rawToHex(x)
```

Arguments

x	raw vector, or list with raw vectors

---

s2 *functions for spherical geometry, using s2 package*

Description

functions for spherical geometry, using the s2 package based on the google s2geometry.io library

Usage

```
sf_use_s2(use_s2)

st_as_s2(x, ...)

## S3 method for class 'sf'
st_as_s2(x, ...)

## S3 method for class 'sfc'
st_as_s2(
  x,
  ...,
  oriented = getOption("s2_oriented", FALSE) || isTRUE(attr(x, "oriented")),
  rebuild = FALSE
)
```

Arguments

use_s2	logical; if TRUE, use the s2 spherical geometry package for geographical coordinate operations
x	object of class sf, sfc or sfg
...	passed on
oriented	logical; if FALSE, polygons that cover more than half of the globe are inverted; if TRUE, no reversal takes place and it is assumed that the inside of the polygon is to the left of the polygon's path.
rebuild	logical; call s2_rebuild on the geometry (think of this as a st_make_valid on the sphere)

Details

st_as_s2 converts an sf POLYGON object into a form readable by s2.

Value

sf_use_s2 returns the value of this variable before (re)setting it, invisibly if use_s2 is not missing.

Examples

```
m = rbind(c(-1,-1), c(1,-1), c(1,1), c(-1,1), c(-1,-1))
m1 = rbind(c(-1,-1), c(1,-1), c(1,1), c(-1,1), c(-1,0), c(-1,-1))
m0 = m[5:1,]
mp = st_multipolygon(list(
list(m, 0.8 * m0, 0.01 * m1 + 0.9),
list(0.7* m, 0.6*m0),
list(0.5 * m0),
list(m+2),
list(m+4,(.9*m0)+4)
))
sf = st_sfc(mp, mp, crs = 'EPSG:4326')
s2 = st_as_s2(sf)
```

---

sf *Create sf object*

Description

Create sf, which extends data.frame-like objects with a simple feature list column. To convert a data frame object to sf, use st_as_sf()

Usage

```
st_sf(
  ...,
  agr = NA_agr_,
  row.names,
  stringsAsFactors = sf_stringsAsFactors(),
  crs,
  precision,
  sf_column_name = NULL,
  check_ring_dir = FALSE,
  sfc_last = TRUE
)

## S3 method for class 'sf'
x[i, j, ..., drop = FALSE, op = st_intersects]

## S3 method for class 'sf'
print(x, ..., n = getOption("sf_max_print", default = 10))
```

Arguments

...	column elements to be binded into an sf object or a single list or data.frame with such columns; at least one of these columns shall be a geometry list-column of class sfc or be a list-column that can be converted into an sfc by st_as_sfc.

agr	character vector; see details below.
row.names	row.names for the created sf object
stringsAsFactors	logical; see st_read
crs	coordinate reference system, something suitable as input to st_crs
precision	numeric; see st_as_binary
sf_column_name	character; name of the active list-column with simple feature geometries; in case there is more than one and sf_column_name is NULL, the first one is taken.
check_ring_dir	see st_read
sfc_last	logical; if TRUE, sfc columns are always put last, otherwise column order is left unmodified.
x	object of class sf
i	record selection, see [.data.frame, or a sf object to work with the op argument
j	variable selection, see [.data.frame
drop	logical, default FALSE; if TRUE drop the geometry column and return a data.frame, else make the geometry sticky and return a sf object.
op	function; geometrical binary predicate function to apply when i is a simple feature object
n	maximum number of features to print; can be set globally by options(sf_max_print=...)

Details

agr, attribute-geometry-relationship, specifies for each non-geometry attribute column how it relates to the geometry, and can have one of following values: "constant", "aggregate", "identity". "constant" is used for attributes that are constant throughout the geometry (e.g. land use), "aggregate" where the attribute is an aggregate value over the geometry (e.g. population density or population count), "identity" when the attributes uniquely identifies the geometry of particular "thing", such as a building ID or a city name. The default value, NA_agr_, implies we don't know.

When a single value is provided to agr, it is cascaded across all input columns; otherwise, a named vector like c(feature1='constant', ...) will set agr value to 'constant' for the input column named feature1. See demo(nc) for a worked example of this.

When confronted with a data.frame-like object, st_sf will try to find a geometry column of class sfc, and otherwise try to convert list-columns when available into a geometry column, using st_as_sfc.

[.sf will return a data.frame or vector if the geometry column (of class sfc) is dropped (drop=TRUE), an sfc object if only the geometry column is selected, and otherwise return an sf object; see also [.data.frame; for [.sf ... arguments are passed to op.

Examples

```
g = st_sfc(st_point(1:2))
st_sf(a=3,g)
st_sf(g, a=3)
st_sf(a=3, st_sfc(st_point(1:2))) # better to name it!
```

```
# create empty structure with preallocated empty geometries:
nrows <- 10
geometry = st_sfc(lapply(1:nrows, function(x) st_geometrycollection()))
df <- st_sf(id = 1:nrows, geometry = geometry)
g = st_sfc(st_point(1:2), st_point(3:4))
s = st_sf(a=3:4, g)
s[1,]
class(s[1,])
s[,1]
class(s[,1])
s[,2]
class(s[,2])
g = st_sf(a=2:3, g)
pol = st_sfc(st_polygon(list(cbind(c(0,3,3,0,0),c(0,0,3,3,0)))))
h = st_sf(r = 5, pol)
g[h,]
h[g,]
```

`sf_extSoftVersion` *Provide the external dependencies versions of the libraries linked to sf*

Description

Provide the external dependencies versions of the libraries linked to sf

Usage

```
sf_extSoftVersion()
```

`sf_project` *directly transform a set of coordinates*

Description

directly transform a set of coordinates

Usage

```
sf_add_proj_units()

sf_project(
  from = character(0),
  to = character(0),
  pts,
  keep = FALSE,
  warn = TRUE,
  authority_compliant = st_axis_order()
)
```

Arguments

from	character description of source CRS, or object of class crs, or pipeline describing a transformation
to	character description of target CRS, or object of class crs
pts	two-, three- or four-column numeric matrix, or object that can be coerced into a matrix; columns 3 and 4 contain z and t values.
keep	logical value controlling the handling of unprojectable points. If keep is TRUE, then such points will yield Inf or -Inf in the return value; otherwise an error is reported and nothing is returned.
warn	logical; if TRUE, warn when non-finite values are generated
authority_compliant	logical; TRUE means handle axis order authority compliant (e.g. EPSG:4326 implying x=lat, y=lon), FALSE means use visualisation order (i.e. always x=lon, y=lat)

Details

sf_add_proj_units loads the PROJ units link, us_in, ind_yd, ind_ft, and ind_ch into the udunits database, and returns TRUE invisibly on success.

Value

two-column numeric matrix with transformed/converted coordinates, returning invalid values as Inf

Examples

```
sf_add_proj_units()
```

---

sfc *Create simple feature geometry list column*

Description

Create simple feature geometry list column, set class, and add coordinate reference system and precision. For data.frame alternatives see st_sf(). To convert a foreign object to sfc, see st_as_sfc()

Usage

```
st_sfc(
  ...,
  crs = NA_crs_,
  precision = 0,
  check_ring_dir = FALSE,
  dim,
  recompute_bbox = FALSE,
```

```
  oriented = NA,
  fall_back_class = c("sfc_GEOMETRY", "sfc")
)

## S3 method for class 'sfc'
x[i, j, ..., op = st_intersects]
```

Arguments

...	input: zero or more simple feature geometries (objects of class sfg), or a single list of such objects; NULL values will get replaced by empty geometries.
crs	coordinate reference system: integer with the EPSG code, or character with proj4string
precision	numeric; see st_as_binary
check_ring_dir	see st_read
dim	character; if this function is called without valid geometries, this argument may carry the right dimension to set empty geometries
recompute_bbox	logical; use TRUE to force recomputation of the bounding box
oriented	logical; if TRUE, the ring is oriented such that left of the edges is inside the polygon; this is needed for convering polygons larger than half the globe to s2
fall_back_class	character; class for return object when no geometries are provided as input
x	object of class sfc
i	record selection. Might also be an sfc/sf object to work with the op argument
j	ignored if op is specified
op	function, geometrical binary predicate function to apply when i is a sf/sfc object. Additional arguments can be specified using ..., see examples.

Details

A simple feature geometry list-column is a list of class c("stc_TYPE", "sfc") which most often contains objects of identical type; in case of a mix of types or an empty set, TYPE is set to the superclass GEOMETRY.

if x has a dim attribute (i.e. is an array or matrix) then op cannot be used.

Value

an object of class sfc, which is a classed list-column with simple feature geometries.

Examples

```
pt1 = st_point(c(0,1))
pt2 = st_point(c(1,1))
(sfc = st_sfc(pt1, pt2))
sfc[sfc[1], op = st_is_within_distance, dist = 0.5]
d = st_sf(data.frame(a=1:2, geom=sfc))
```

sgbp *Methods for dealing with sparse geometry binary predicate lists*

Description

Methods for dealing with sparse geometry binary predicate lists

Usage

```
## S3 method for class 'sgbp'
print(x, ..., n = 10, max_nb = 10)

## S3 method for class 'sgbp'
t(x)

## S3 method for class 'sgbp'
as.matrix(x, ...)

## S3 method for class 'sgbp'
dim(x)

## S3 method for class 'sgbp'
Ops(e1, e2)

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

Arguments

x	object of class sgbp
...	ignored
n	integer; maximum number of items to print
max_nb	integer; maximum number of neighbours to print for each item
e1	object of class sgbp
e2	object of class sgbp

Details

sgbp are sparse matrices, stored as a list with integer vectors holding the ordered TRUE indices of each row. This means that for a dense, $m \times n$ matrix Q and a list L, if Q[i,j] is TRUE then j is an element of L[[i]]. Reversed: when k is the value of L[[i]][j], then Q[i,k] is TRUE.

== compares only the dimension and index values, not the attributes of two sgbp object; use identical to check for equality of everything.

st *Create simple feature from a numeric vector, matrix or list*

Description

Create simple feature from a numeric vector, matrix or list

Usage

```
st_point(x = c(NA_real_, NA_real_), dim = "XYZ")

st_multipoint(x = matrix(numeric(0), 0, 2), dim = "XYZ")

st_linestring(x = matrix(numeric(0), 0, 2), dim = "XYZ")

st_polygon(x = list(), dim = if (length(x)) "XYZ" else "XY")

st_multilinestring(x = list(), dim = if (length(x)) "XYZ" else "XY")

st_multipolygon(x = list(), dim = if (length(x)) "XYZ" else "XY")

st_geometrycollection(x = list(), dims = "XY")

## S3 method for class 'sfg'
print(x, ..., width = 0)

## S3 method for class 'sfg'
head(x, n = 10L, ...)

## S3 method for class 'sfg'
format(x, ..., width = 30)

## S3 method for class 'sfg'
c(..., recursive = FALSE, flatten = TRUE)

## S3 method for class 'sfg'
as.matrix(x, ...)
```

Arguments

x	for st_point, numeric vector (or one-row-matrix) of length 2, 3 or 4; for st_linestring and st_multipoint, numeric matrix with points in rows; for st_polygon and st_multilinestring, list with numeric matrices with points in rows; for st_multipolygon, list of lists with numeric matrices; for st_geometrycollection list with (non-geometrycollection) simple feature geometry (sfg) objects; see examples below

dim	character, indicating dimensions: "XY", "XYZ", "XYM", or "XYZM"; only really needed for three-dimensional points (which can be either XYZ or XYM) or empty geometries; see details
dims	character; specify dimensionality in case of an empty (NULL) geometrycollection, in which case x is the empty list().
...	objects to be pasted together into a single simple feature
width	integer; number of characters to be printed (max 30; 0 means print everything)
n	integer; number of elements to be selected
recursive	logical; ignored
flatten	logical; if TRUE, try to simplify results; if FALSE, return geometrycollection containing all objects

Details

"XYZ" refers to coordinates where the third dimension represents altitude, "XYM" refers to three-dimensional coordinates where the third dimension refers to something else ("M" for measure); checking of the sanity of x may be only partial.

When flatten=TRUE, this method may merge points into a multipoint structure, and may not preserve order, and hence cannot be reverted. When given fish, it returns fish soup.

Value

object of the same nature as x, but with appropriate class attribute set

as.matrix returns the set of points that form a geometry as a single matrix, where each point is a row; use unlist(x, recursive = FALSE) to get sets of matrices.

Examples

```
(p1 = st_point(c(1,2)))
class(p1)
st_bbox(p1)
(p2 = st_point(c(1,2,3)))
class(p2)
(p3 = st_point(c(1,2,3), "XYM"))
pts = matrix(1:10, , 2)
(mp1 = st_multipoint(pts))
pts = matrix(1:15, , 3)
(mp2 = st_multipoint(pts))
(mp3 = st_multipoint(pts, "XYM"))
pts = matrix(1:20, , 4)
(mp4 = st_multipoint(pts))
pts = matrix(1:10, , 2)
(ls1 = st_linestring(pts))
pts = matrix(1:15, , 3)
(ls2 = st_linestring(pts))
(ls3 = st_linestring(pts, "XYM"))
pts = matrix(1:20, , 4)
(ls4 = st_linestring(pts))
```

```
outer = matrix(c(0,0,10,0,10,10,0,10,0,0),ncol=2, byrow=TRUE)
hole1 = matrix(c(1,1,1,2,2,2,1,1,1),ncol=2, byrow=TRUE)
hole2 = matrix(c(5,5,5,6,6,6,5,5,5),ncol=2, byrow=TRUE)
pts = list(outer, hole1, hole2)
(ml1 = st_multilinestring(pts))
pts3 = lapply(pts, function(x) cbind(x, 0))
(ml2 = st_multilinestring(pts3))
(ml3 = st_multilinestring(pts3, "XYM"))
pts4 = lapply(pts3, function(x) cbind(x, 0))
(ml4 = st_multilinestring(pts4))
outer = matrix(c(0,0,10,0,10,10,0,10,0,0),ncol=2, byrow=TRUE)
hole1 = matrix(c(1,1,1,2,2,2,1,1,1),ncol=2, byrow=TRUE)
hole2 = matrix(c(5,5,5,6,6,6,5,5,5),ncol=2, byrow=TRUE)
pts = list(outer, hole1, hole2)
(pl1 = st_polygon(pts))
pts3 = lapply(pts, function(x) cbind(x, 0))
(pl2 = st_polygon(pts3))
(pl3 = st_polygon(pts3, "XYM"))
pts4 = lapply(pts3, function(x) cbind(x, 0))
(pl4 = st_polygon(pts4))
pol1 = list(outer, hole1, hole2)
pol2 = list(outer + 12, hole1 + 12)
pol3 = list(outer + 24)
mp = list(pol1,pol2,pol3)
(mp1 = st_multipolygon(mp))
pts3 = lapply(mp, function(x) lapply(x, function(y) cbind(y, 0)))
(mp2 = st_multipolygon(pts3))
(mp3 = st_multipolygon(pts3, "XYM"))
pts4 = lapply(mp2, function(x) lapply(x, function(y) cbind(y, 0)))
(mp4 = st_multipolygon(pts4))
(gc = st_geometrycollection(list(p1, ls1, pl1, mp1)))
st_geometrycollection() # empty geometry
c(st_point(1:2), st_point(5:6))
c(st_point(1:2), st_multipoint(matrix(5:8,2)))
c(st_multipoint(matrix(1:4,2)), st_multipoint(matrix(5:8,2)))
c(st_linestring(matrix(1:6,3)), st_linestring(matrix(11:16,3)))
c(st_multilinestring(list(matrix(1:6,3))), st_multilinestring(list(matrix(11:16,3))))
pl = list(rbind(c(0,0), c(1,0), c(1,1), c(0,1), c(0,0)))
c(st_polygon(pl), st_polygon(pl))
c(st_polygon(pl), st_multipolygon(list(pl)))
c(st_linestring(matrix(1:6,3)), st_point(1:2))
c(st_geometrycollection(list(st_point(1:2), st_linestring(matrix(1:6,3)))),
  st_geometrycollection(list(st_multilinestring(list(matrix(11:16,3))))))
c(st_geometrycollection(list(st_point(1:2), st_linestring(matrix(1:6,3)))),
  st_multilinestring(list(matrix(11:16,3))), st_point(5:6),
  st_geometrycollection(list(st_point(10:11))))
```

---

st_agr *get or set relation_to_geometry attribute of an* sf *object*

Description

get or set relation_to_geometry attribute of an sf object

Usage

```
NA_agr_

st_agr(x, ...)

st_agr(x) <- value

st_set_agr(x, value)
```

Arguments

x	object of class sf
...	ignored
value	character, or factor with appropriate levels; if named, names should correspond to the non-geometry list-column columns of x

Details

NA_agr_ is the agr object with a missing value.

---

st_as_binary *Convert sfc object to an WKB object*

Description

Convert sfc object to an WKB object

Usage

```
st_as_binary(x, ...)

## S3 method for class 'sfc'
st_as_binary(
  x,
  ...,
  EWKB = FALSE,
  endian = .Platform$endian,
  pureR = FALSE,
  precision = attr(x, "precision"),
  hex = FALSE
)
```

```
## S3 method for class 'sfg'
st_as_binary(
  x,
  ...,
  endian = .Platform$endian,
  EWKB = FALSE,
  pureR = FALSE,
  hex = FALSE,
  srid = 0
)
```

Arguments

x	object to convert
...	ignored
EWKB	logical; use EWKB (PostGIS), or (default) ISO-WKB?
endian	character; either "big" or "little"; default: use that of platform
pureR	logical; use pure R solution, or C++?
precision	numeric; if zero, do not modify; to reduce precision: negative values convert to float (4-byte real); positive values convert to round(x*precision)/precision. See details.
hex	logical; return as (unclassed) hexadecimal encoded character vector?
srid	integer; override srid (can be used when the srid is unavailable locally).

Details

`st_as_binary` is called on sfc objects on their way to the GDAL or GEOS libraries, and hence does rounding (if requested) on the fly before e.g. computing spatial predicates like st_intersects. The examples show a round-trip of an `sfc` to and from binary.

For the precision model used, see also https://locationtech.github.io/jts/javadoc/org/locationtech/jts/geom/PrecisionModel.html. There, it is written that: "... to specify 3 decimal places of precision, use a scale factor of 1000. To specify -3 decimal places of precision (i.e. rounding to the nearest 1000), use a scale factor of 0.001.". Note that ALL coordinates, so also Z or M values (if present) are affected.

Examples

```
# examples of setting precision:
st_point(c(1/3, 1/6)) |> st_sfc(precision = 1000) |> st_as_binary() |> st_as_sfc()
st_point(c(1/3, 1/6)) |> st_sfc(precision =  100) |> st_as_binary() |> st_as_sfc()
st_point(1e6 * c(1/3, 1/6)) |> st_sfc(precision = 0.01) |> st_as_binary() |> st_as_sfc()
st_point(1e6 * c(1/3, 1/6)) |> st_sfc(precision = 0.001) |> st_as_binary() |> st_as_sfc()
```

st_as_grob *Convert sf* object to a grob*

Description

Convert sf* object to an grid graphics object (grob)

Usage

```
st_as_grob(x, ...)
```

Arguments

x	object to be converted into an object class grob
...	passed on to the xxxGrob function, e.g. gp = gpar(col = 'red')

st_as_sf *Convert foreign object to an sf object*

Description

Convert foreign object to an sf object

Usage

```
st_as_sf(x, ...)

## S3 method for class 'data.frame'
st_as_sf(
  x,
  ...,
  agr = NA_agr_,
  coords,
  wkt,
  dim = "XYZ",
  remove = TRUE,
  na.fail = TRUE,
  sf_column_name = NULL
)

## S3 method for class 'sf'
st_as_sf(x, ...)

## S3 method for class 'sfc'
st_as_sf(x, ...)
```

```
## S3 method for class 'Spatial'
st_as_sf(x, ...)

## S3 method for class 'map'
st_as_sf(x, ..., fill = TRUE, group = TRUE)

## S3 method for class 'ppp'
st_as_sf(x, ...)

## S3 method for class 'psp'
st_as_sf(x, ...)

## S3 method for class 'lpp'
st_as_sf(x, ...)

## S3 method for class 's2_geography'
st_as_sf(x, ..., crs = st_crs(4326))
```

Arguments

x	object to be converted into an object class sf
...	passed on to st_sf, might included named arguments crs or precision
agr	character vector; see details section of st_sf
coords	in case of point data: names or numbers of the numeric columns holding coordinates
wkt	name or number of the character column that holds WKT encoded geometries
dim	specify what 3- or 4-dimensional points reflect: passed on to st_point (only when argument coords is given)
remove	logical; when coords or wkt is given, remove these columns from data.frame?
na.fail	logical; if TRUE, raise an error if coordinates contain missing values
sf_column_name	character; name of the active list-column with simple feature geometries; in case there is more than one and sf_column_name is NULL, the first one is taken.
fill	logical; the value for fill that was used in the call to map.
group	logical; if TRUE, group id labels from map by their prefix before :
crs	coordinate reference system to be assigned; object of class crs

Details

setting argument wkt annihilates the use of argument coords. If x contains a column called "geometry", coords will result in overwriting of this column by the sfc geometry list-column. Setting wkt will replace this column with the geometry list-column, unless remove is FALSE.

If coords has length 4, and dim is not XYZM, the four columns are taken as the xmin, ymin, xmax, ymax corner coordinates of a rectangle, and polygons are returned.

Examples

```
pt1 = st_point(c(0,1))
pt2 = st_point(c(1,1))
st_sfc(pt1, pt2)
d = data.frame(a = 1:2)
d$geom = st_sfc(pt1, pt2)
df = st_as_sf(d)
d$geom = c("POINT(0 0)", "POINT(0 1)")
df = st_as_sf(d, wkt = "geom")
d$geom2 = st_sfc(pt1, pt2)
st_as_sf(d) # should warn
if (require(sp, quietly = TRUE)) {
 data(meuse, package = "sp")
 meuse_sf = st_as_sf(meuse, coords = c("x", "y"), crs = 28992, agr = "constant")
 meuse_sf[1:3,]
 summary(meuse_sf)
}
if (require(sp, quietly = TRUE)) {
x = rbind(c(-1,-1), c(1,-1), c(1,1), c(-1,1), c(-1,-1))
x1 = 0.1 * x + 0.1
x2 = 0.1 * x + 0.4
x3 = 0.1 * x + 0.7
y = x + 3
y1 = x1 + 3
y3 = x3 + 3
m = matrix(c(3, 0), 5, 2, byrow = TRUE)
z = x + m
z1 = x1 + m
z2 = x2 + m
z3 = x3 + m
p1 = Polygons(list( Polygon(x[5:1,]), Polygon(x2), Polygon(x3),
   Polygon(y[5:1,]), Polygon(y1), Polygon(x1), Polygon(y3)), "ID1")
p2 = Polygons(list( Polygon(z[5:1,]), Polygon(z2), Polygon(z3), Polygon(z1)),
  "ID2")
r = SpatialPolygons(list(p1,p2))
a = suppressWarnings(st_as_sf(r))
summary(a)
demo(meuse, ask = FALSE, echo = FALSE)
summary(st_as_sf(meuse))
summary(st_as_sf(meuse.grid))
summary(st_as_sf(meuse.area))
summary(st_as_sf(meuse.riv))
summary(st_as_sf(as(meuse.riv, "SpatialLines")))
pol.grd = as(meuse.grid, "SpatialPolygonsDataFrame")
# summary(st_as_sf(pol.grd))
# summary(st_as_sf(as(pol.grd, "SpatialLinesDataFrame")))
}
if (require(spatstat.geom)) {
  g = st_as_sf(gorillas)
  # select only the points:
  g[st_is(g, "POINT"),]
}
```

```
if (require(spatstat.linnet)) {
 data(chicago)
 plot(st_as_sf(chicago)["label"])
 plot(st_as_sf(chicago)[-1,"label"])
}
```

---

st_as_sfc *Convert foreign geometry object to an sfc object*

Description

Convert foreign geometry object to an sfc object

Usage

```
## S3 method for class 'pq_geometry'
st_as_sfc(
  x,
  ...,
  EWKB = TRUE,
  spatialite = FALSE,
  pureR = FALSE,
  crs = NA_crs_
)

## S3 method for class 'list'
st_as_sfc(x, ..., crs = NA_crs_)

## S3 method for class 'blob'
st_as_sfc(x, ...)

## S3 method for class 'bbox'
st_as_sfc(x, ...)

## S3 method for class 'WKB'
st_as_sfc(
  x,
  ...,
  EWKB = FALSE,
  spatialite = FALSE,
  pureR = FALSE,
  crs = NA_crs_
)

## S3 method for class 'raw'
st_as_sfc(x, ...)
```

```
## S3 method for class 'character'
st_as_sfc(x, crs = NA_integer_, ..., GeoJSON = FALSE)

## S3 method for class 'factor'
st_as_sfc(x, ...)

st_as_sfc(x, ...)

## S3 method for class 'SpatialPoints'
st_as_sfc(x, ..., precision = 0)

## S3 method for class 'SpatialPixels'
st_as_sfc(x, ..., precision = 0)

## S3 method for class 'SpatialMultiPoints'
st_as_sfc(x, ..., precision = 0)

## S3 method for class 'SpatialLines'
st_as_sfc(x, ..., precision = 0, forceMulti = FALSE)

## S3 method for class 'SpatialPolygons'
st_as_sfc(x, ..., precision = 0, forceMulti = FALSE)

## S3 method for class 'map'
st_as_sfc(x, ...)

## S3 method for class 's2_geography'
st_as_sfc(
  x,
  ...,
  crs = st_crs(4326),
  endian = match(.Platform$endian, c("big", "little")) - 1L
)
```

Arguments

x	object to convert
...	further arguments
EWKB	logical; if TRUE, parse as EWKB (extended WKB; PostGIS: ST_AsEWKB), otherwise as ISO WKB (PostGIS: ST_AsBinary)
spatialite	logical; if TRUE, WKB is assumed to be in the spatialite dialect, see https://www.gaia-gis.it/gaia-sins/BLOB-Geometry.html; this is only supported in native endian-ness (i.e., files written on system with the same endian-ness as that on which it is being read).
pureR	logical; if TRUE, use only R code, if FALSE, use compiled (C++) code; use TRUE when the endian-ness of the binary differs from the host machine (.Platform$endian).
crs	coordinate reference system to be assigned; object of class crs

GeoJSON	logical; if TRUE, try to read geometries from GeoJSON text strings geometry, see st_crs()
precision	precision value; see st_as_binary
forceMulti	logical; if TRUE, force coercion into MULTIPOLYGON or MULTILINE objects, else autodetect
endian	integer; 0 or 1: defaults to the endian of the native machine

Details

When converting from WKB, the object x is either a character vector such as typically obtained from PostGIS (either with leading "0x" or without), or a list with raw vectors representing the features in binary (raw) form.

If x is a character vector, it should be a vector containing well-known-text, or Postgis EWKT or GeoJSON representations of a single geometry for each vector element.

If x is a factor, it is converted to character.

Examples

```
wkb = structure(list("0101000020407100000000000000801A064100000000AC5C1441"), class = "WKB")
st_as_sfc(wkb, EWKB = TRUE)
wkb = structure(list("0x0101000020407100000000000000801A064100000000AC5C1441"), class = "WKB")
st_as_sfc(wkb, EWKB = TRUE)
st_as_sfc(st_as_binary(st_sfc(st_point(0:1)))[[1]], crs = 4326)
st_as_sfc("SRID=3978;LINESTRING(1663106 -105415,1664320 -104617)")
```

---

st_as_text *Return Well-known Text representation of simple feature geometry or coordinate reference system*

Description

Return Well-known Text representation of simple feature geometry or coordinate reference system

Usage

```
## S3 method for class 'crs'
st_as_text(x, ..., projjson = FALSE, pretty = FALSE)

st_as_text(x, ...)

## S3 method for class 'sfg'
st_as_text(x, ...)

## S3 method for class 'sfc'
st_as_text(x, ..., EWKT = FALSE)
```

Arguments

x	object of class sfg, sfc or crs
...	modifiers; in particular digits can be passed to control the number of digits used
projjson	logical; if TRUE, return projjson form (requires GDAL 3.1 and PROJ 6.2), else return well-known-text form
pretty	logical; if TRUE, print human-readable well-known-text representation of a coordinate reference system
EWKT	logical; if TRUE, print SRID=xxx; before the WKT string if epsg is available

Details

The returned WKT representation of simple feature geometry conforms to the simple features access specification and extensions (known as EWKT, supported by PostGIS and other simple features implementations for addition of a SRID to a WKT string).

Note

To improve conversion performance, the lwgeom package can be used (it must be installed beforehand) and set the `Sys.setenv("LWGEOM_WKT" = "true")` environment variable. This will also result in faster printing of complex geometries. Note that the representation as WKT is different from the sf package and may cause reproducibility problems. An alternative solution is to use the `lwgeom::st_astext()` or `wk::as_wkt()` functions.

Examples

```
st_as_text(st_point(1:2))
st_as_text(st_sfc(st_point(c(-90,40)), crs = 4326), EWKT = TRUE)
```

---

st_bbox *Return bounding of a simple feature or simple feature set*

Description

Return bounding of a simple feature or simple feature set

Usage

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

st_bbox(obj, ...)

## S3 method for class 'POINT'
st_bbox(obj, ...)
```

```
## S3 method for class 'MULTIPOINT'
st_bbox(obj, ...)

## S3 method for class 'LINESTRING'
st_bbox(obj, ...)

## S3 method for class 'POLYGON'
st_bbox(obj, ...)

## S3 method for class 'MULTILINESTRING'
st_bbox(obj, ...)

## S3 method for class 'MULTIPOLYGON'
st_bbox(obj, ...)

## S3 method for class 'GEOMETRYCOLLECTION'
st_bbox(obj, ...)

## S3 method for class 'MULTISURFACE'
st_bbox(obj, ...)

## S3 method for class 'MULTICURVE'
st_bbox(obj, ...)

## S3 method for class 'CURVEPOLYGON'
st_bbox(obj, ...)

## S3 method for class 'COMPOUNDCURVE'
st_bbox(obj, ...)

## S3 method for class 'POLYHEDRALSURFACE'
st_bbox(obj, ...)

## S3 method for class 'TIN'
st_bbox(obj, ...)

## S3 method for class 'TRIANGLE'
st_bbox(obj, ...)

## S3 method for class 'CIRCULARSTRING'
st_bbox(obj, ...)

## S3 method for class 'sfc'
st_bbox(obj, ...)

## S3 method for class 'sf'
st_bbox(obj, ...)
```

```
## S3 method for class 'Spatial'
st_bbox(obj, ...)

## S3 method for class 'Raster'
st_bbox(obj, ...)

## S3 method for class 'Extent'
st_bbox(obj, ..., crs = NA_crs_)

## S3 method for class 'numeric'
st_bbox(obj, ..., crs = NA_crs_)

NA_bbox_

FULL_bbox_

## S3 method for class 'bbox'
format(x, ...)
```

Arguments

x	object of class bbox
obj	object to compute the bounding box from
...	for format.bbox, passed on to format to format individual numbers
crs	object of class crs, or argument to st_crs, specifying the CRS of this bounding box.

Details

NA_bbox_ represents the missing value for a bbox object

NA_bbox_ represents the missing value for a bbox object

Value

a numeric vector of length four, with xmin, ymin, xmax and ymax values; if obj is of class sf, sfc, Spatial or Raster, the object returned has a class bbox, an attribute crs and a method to print the bbox and an st_crs method to retrieve the coordinate reference system corresponding to obj (and hence the bounding box). st_as_sfc has a methods for bbox objects to generate a polygon around the four bounding box points.

Examples

```
a = st_sf(a = 1:2, geom = st_sfc(st_point(0:1), st_point(1:2)), crs = 4326)
st_bbox(a)
st_as_sfc(st_bbox(a))
st_bbox(c(xmin = 16.1, xmax = 16.6, ymax = 48.6, ymin = 47.9), crs = st_crs(4326))
```

st_break_antimeridian *Break antimeridian for plotting not centred on Greenwich*

Description

Longitudes can be broken at the antimeridian of a target central longitude to permit plotting of (usually world) line or polygon objects centred on the chosen central longitude. The method may only be used with non-projected, geographical coordinates and linestring or polygon objects. s2 is turned off internally to permit the use of a rectangular bounding box. If the input geometries go outside `[-180, 180]` degrees longitude, the protruding geometries will also be split using the same `tol=` values; in this case empty geometries will be dropped first.

Usage

```
st_break_antimeridian(x, lon_0 = 0, tol = 1e-04, ...)

## S3 method for class 'sf'
st_break_antimeridian(x, lon_0 = 0, tol = 1e-04, ...)

## S3 method for class 'sfc'
st_break_antimeridian(x, lon_0 = 0, tol = 1e-04, ...)
```

Arguments

`x`	object of class `sf` or `sfc`
`lon_0`	target central longitude (degrees)
`tol`	half of break width (degrees, default 0.0001)
`...`	ignored here

Examples

```
if (require("maps", quietly=TRUE)) {
 opar = par(mfrow=c(3, 2))
 wld = st_as_sf(map(fill=FALSE, interior=FALSE, plot=FALSE), fill=FALSE)
 for (lon_0 in c(-170, -90, -10, 10, 90, 170)) {
   br = st_break_antimeridian(wld, lon_0 = lon_0)
   tr = st_transform(br, paste0("+proj=natearth +lon_0=", lon_0))
   plot(st_geometry(tr), main=lon_0)
 }
 par(opar)
}
```

st_cast *Cast geometry to another type: either simplify, or cast explicitly*

Description

Cast geometry to another type: either simplify, or cast explicitly

Usage

```
## S3 method for class 'MULTIPOLYGON'
st_cast(x, to, ...)

## S3 method for class 'MULTILINESTRING'
st_cast(x, to, ...)

## S3 method for class 'MULTIPOINT'
st_cast(x, to, ...)

## S3 method for class 'POLYGON'
st_cast(x, to, ...)

## S3 method for class 'LINESTRING'
st_cast(x, to, ...)

## S3 method for class 'POINT'
st_cast(x, to, ...)

## S3 method for class 'GEOMETRYCOLLECTION'
st_cast(x, to, ...)

## S3 method for class 'CIRCULARSTRING'
st_cast(x, to, ...)

## S3 method for class 'MULTISURFACE'
st_cast(x, to, ...)

## S3 method for class 'COMPOUNDCURVE'
st_cast(x, to, ...)

## S3 method for class 'MULTICURVE'
st_cast(x, to, ...)

## S3 method for class 'CURVE'
st_cast(x, to, ...)

st_cast(x, to, ...)
```

```
## S3 method for class 'sfc'
st_cast(x, to, ..., ids = seq_along(x), group_or_split = TRUE)

## S3 method for class 'sf'
st_cast(x, to, ..., warn = TRUE, do_split = TRUE)

## S3 method for class 'sfc_CIRCULARSTRING'
st_cast(x, to, ...)
```

Arguments

x	object of class sfg, sfc or sf
to	character; target type, if missing, simplification is tried; when x is of type sfg (i.e., a single geometry) then to needs to be specified.
...	ignored
ids	integer vector, denoting how geometries should be grouped (default: no grouping)
group_or_split	logical; if TRUE, group or split geometries; if FALSE, carry out a 1-1 per-geometry conversion.
warn	logical; if TRUE, warn if attributes are assigned to sub-geometries
do_split	logical; if TRUE, allow splitting of geometries in sub-geometries

Details

When converting a GEOMETRYCOLLECTION to COMPOUNDCURVE, MULTISURFACE or CURVEPOLYGON, the user is responsible for the validity of the resulting object: no checks are being carried out by the software.

When converting mixed, GEOMETRY sets, it may help to first convert to the MULTI-type, see examples

the st_cast method for sf objects can only split geometries, e.g. cast MULTIPOINT into multiple POINT features. In case of splitting, attributes are repeated and a warning is issued when non-constant attributes are assigned to sub-geometries. To merge feature geometries and attribute values, use aggregate or summarise.

Value

object of class to if successful, or unmodified object if unsuccessful. If information gets lost while type casting, a warning is raised.

In case to is missing, st_cast.sfc will coerce combinations of "POINT" and "MULTIPOINT", "LINESTRING" and "MULTILINESTRING", "POLYGON" and "MULTIPOLYGON" into their "MULTI..." form, or in case all geometries are "GEOMETRYCOLLECTION" will return a list of all the contents of the "GEOMETRYCOLLECTION" objects, or else do nothing. In case to is specified, if to is "GEOMETRY", geometries are not converted, else, st_cast will try to coerce all elements into to; ids may be specified to group e.g. "POINT" objects into a "MULTIPOINT", if not specified no grouping takes place. If e.g. a "sfc_MULTIPOINT" is cast to a "sfc_POINT", the objects are split, so no information gets lost, unless group_or_split is FALSE.

Examples

```
# example(st_read)
nc = st_read(system.file("shape/nc.shp", package="sf"))
mpl <- st_geometry(nc)[[4]]
#st_cast(x) ## error 'argument "to" is missing, with no default'
cast_all <- function(xg) {
 lapply(c("MULTIPOLYGON", "MULTILINESTRING", "MULTIPOINT", "POLYGON", "LINESTRING", "POINT"),
      function(x) st_cast(xg, x))
}
st_sfc(cast_all(mpl))
## no closing coordinates should remain for multipoint
any(duplicated(unclass(st_cast(mpl, "MULTIPOINT"))))  ## should be FALSE
## number of duplicated coordinates in the linestrings should equal the number of polygon rings
## (... in this case, won't always be true)
sum(duplicated(do.call(rbind, unclass(st_cast(mpl, "MULTILINESTRING"))))
     ) == sum(unlist(lapply(mpl, length)))  ## should be TRUE

p1 <- structure(c(0, 1, 3, 2, 1, 0, 0, 0, 2, 4, 4, 0), .Dim = c(6L, 2L))
p2 <- structure(c(1, 1, 2, 1, 1, 2, 2, 1), .Dim = c(4L, 2L))
st_polygon(list(p1, p2))
mls <- st_cast(st_geometry(nc)[[4]], "MULTILINESTRING")
st_sfc(cast_all(mls))
mpt <- st_cast(st_geometry(nc)[[4]], "MULTIPOINT")
st_sfc(cast_all(mpt))
pl <- st_cast(st_geometry(nc)[[4]], "POLYGON")
st_sfc(cast_all(pl))
ls <- st_cast(st_geometry(nc)[[4]], "LINESTRING")
st_sfc(cast_all(ls))
pt <- st_cast(st_geometry(nc)[[4]], "POINT")
## st_sfc(cast_all(pt))  ## Error: cannot create MULTIPOLYGON from POINT
st_sfc(lapply(c("POINT", "MULTIPOINT"), function(x) st_cast(pt, x)))
s = st_multipoint(rbind(c(1,0)))
st_cast(s, "POINT")
# https://github.com/r-spatial/sf/issues/1930:
pt1 <- st_point(c(0,1))
pt23 <- st_multipoint(matrix(c(1,2,3,4), ncol = 2, byrow = TRUE))
d <- st_sf(geom = st_sfc(pt1, pt23))
st_cast(d, "POINT") # will not convert the entire MULTIPOINT, and warns
st_cast(d, "MULTIPOINT") |> st_cast("POINT")
```

`st_cast_sfc_default` *Coerce geometry to MULTI* geometry*

Description

Mixes of POINTS and MULTIPOINTS, LINESTRING and MULTILINESTRING, POLYGON and MULTIPOLYGON are returned as MULTIPOINTS, MULTILINESTRING and MULTIPOLYGONS respectively

Usage

```
st_cast_sfc_default(x)
```

Arguments

x	list of geometries or simple features

Details

Geometries that are already MULTI* are left unchanged. Features that can't be cast to a single MULTI* geometry are return as a GEOMETRYCOLLECTION

---

st_collection_extract *Given an object with geometries of type* GEOMETRY *or* GEOMETRYCOLLECTION*, return an object consisting only of elements of the specified type.*

Description

Similar to ST_CollectionExtract in PostGIS. If there are no sub-geometries of the specified type, an empty geometry is returned.

Usage

```
st_collection_extract(
  x,
  type = c("POLYGON", "POINT", "LINESTRING"),
  warn = FALSE
)

## S3 method for class 'sfg'
st_collection_extract(
  x,
  type = c("POLYGON", "POINT", "LINESTRING"),
  warn = FALSE
)

## S3 method for class 'sfc'
st_collection_extract(
  x,
  type = c("POLYGON", "POINT", "LINESTRING"),
  warn = FALSE
)

## S3 method for class 'sf'
st_collection_extract(
  x,
```

```
  type = c("POLYGON", "POINT", "LINESTRING"),
  warn = FALSE
)
```

Arguments

x	an object of class sf, sfc or sfg that has mixed geometry (GEOMETRY or GEOMETRYCOLLECTION).
type	character; one of "POLYGON", "POINT", "LINESTRING"
warn	logical; if TRUE, warn if attributes are assigned to sub-geometries when casting (see st_cast)

Value

An object having the same class as x, with geometries consisting only of elements of the specified type. For sfg objects, an sfg object is returned if there is only one geometry of the specified type, otherwise the geometries are combined into an sfc object of the relevant type. If any subgeometries in the input are MULTI, then all of the subgeometries in the output will be MULTI.

Examples

```
pt <- st_point(c(1, 0))
ls <- st_linestring(matrix(c(4, 3, 0, 0), ncol = 2))
poly1 <- st_polygon(list(matrix(c(5.5, 7, 7, 6, 5.5, 0, 0, -0.5, -0.5, 0), ncol = 2)))
poly2 <- st_polygon(list(matrix(c(6.6, 8, 8, 7, 6.6, 1, 1, 1.5, 1.5, 1), ncol = 2)))
multipoly <- st_multipolygon(list(poly1, poly2))

i <- st_geometrycollection(list(pt, ls, poly1, poly2))
j <- st_geometrycollection(list(pt, ls, poly1, poly2, multipoly))

st_collection_extract(i, "POLYGON")
st_collection_extract(i, "POINT")
st_collection_extract(i, "LINESTRING")

## A GEOMETRYCOLLECTION
aa <- rbind(st_sf(a=1, geom = st_sfc(i)),
   st_sf(a=2, geom = st_sfc(j)))

## With sf objects
st_collection_extract(aa, "POLYGON")
st_collection_extract(aa, "LINESTRING")
st_collection_extract(aa, "POINT")

## With sfc objects
st_collection_extract(st_geometry(aa), "POLYGON")
st_collection_extract(st_geometry(aa), "LINESTRING")
st_collection_extract(st_geometry(aa), "POINT")

## A GEOMETRY of single types
bb <- rbind(
 st_sf(a = 1, geom = st_sfc(pt)),
 st_sf(a = 2, geom = st_sfc(ls)),
```

```
 st_sf(a = 3, geom = st_sfc(poly1)),
 st_sf(a = 4, geom = st_sfc(multipoly))
)

st_collection_extract(bb, "POLYGON")

## A GEOMETRY of mixed single types and GEOMETRYCOLLECTIONS
cc <- rbind(aa, bb)

st_collection_extract(cc, "POLYGON")
```

`st_coordinates` *retrieve coordinates in matrix form*

Description

retrieve coordinates in matrix form

Usage

```
st_coordinates(x, ...)
```

Arguments

`x`	object of class sf, sfc or sfg
`...`	ignored

Value

matrix with coordinates (X, Y, possibly Z and/or M) in rows, possibly followed by integer indicators `L1`,...,`L3` that point out to which structure the coordinate belongs; for `POINT` this is absent (each coordinate is a feature), for `LINESTRING` `L1` refers to the feature, for `MULTILINESTRING` `L1` refers to the part and `L2` to the simple feature, for `POLYGON` `L1` refers to the main ring or holes and `L2` to the simple feature, for `MULTIPOLYGON` `L1` refers to the main ring or holes, `L2` to the ring id in the `MULTIPOLYGON`, and `L3` to the simple feature.

For `POLYGONS`, `L1` can be used to identify exterior rings and inner holes. The exterior ring is when `L1` is equal to 1. Interior rings are identified when `L1` is greater than 1. `L2` can be used to differentiate between the feature. Whereas for `MULTIPOLYGON`, `L3` refers to the `MULTIPOLYGON` feature and `L2` refers to the component `POLYGON`.

st_crop *crop an sf object to a specific rectangle*

Description

crop an sf object to a specific rectangle

Usage

```
st_crop(x, y, ...)

## S3 method for class 'sfc'
st_crop(x, y, ..., xmin, ymin, xmax, ymax)

## S3 method for class 'sf'
st_crop(x, y, ...)
```

Arguments

x	object of class sf or sfc
y	numeric vector with named elements xmin, ymin, xmax and ymax, or object of class bbox, or object for which there is an st_bbox method to convert it to a bbox object
...	ignored
xmin	minimum x extent of cropping area
ymin	minimum y extent of cropping area
xmax	maximum x extent of cropping area
ymax	maximum y extent of cropping area

Details

setting arguments xmin, ymin, xmax and ymax implies that argument y gets ignored.

Examples

```
box = c(xmin = 0, ymin = 0, xmax = 1, ymax = 1)
pol = st_sfc(st_buffer(st_point(c(.5, .5)), .6))
pol_sf = st_sf(a=1, geom=pol)
plot(st_crop(pol, box))
plot(st_crop(pol_sf, st_bbox(box)))
# alternative:
plot(st_crop(pol, xmin = 0, ymin = 0, xmax = 1, ymax = 1))
```

st_crs *Retrieve coordinate reference system from object*

Description

Retrieve coordinate reference system from sf or sfc object

Set or replace retrieve coordinate reference system from object

Usage

```
st_crs(x, ...)

## S3 method for class 'sf'
st_crs(x, ...)

## S3 method for class 'numeric'
st_crs(x, ...)

## S3 method for class 'character'
st_crs(x, ...)

## S3 method for class 'sfc'
st_crs(x, ..., parameters = FALSE)

## S3 method for class 'bbox'
st_crs(x, ...)

## S3 method for class 'CRS'
st_crs(x, ...)

## S3 method for class 'crs'
st_crs(x, ...)

st_crs(x) <- value

## S3 replacement method for class 'sf'
st_crs(x) <- value

## S3 replacement method for class 'sfc'
st_crs(x) <- value

st_set_crs(x, value)

NA_crs_

## S3 method for class 'crs'
```

```
is.na(x)

## S3 method for class 'crs'
x$name

## S3 method for class 'crs'
format(x, ...)

st_axis_order(authority_compliant = logical(0))
```

Arguments

x	numeric, character, or object of class sf or sfc
...	ignored
parameters	logical; FALSE by default; only for the st_crs.sfc() method: if TRUE return a classed list of coordinate reference system parameters, with named elements SemiMajor, InvFlattening, units_gdal, IsVertical, WktPretty, Wkt, Name, proj4string, epsg, yx, ProjJson, WKT1_ESRI, srid (in authority:code form), axes (a data.frame with columns name and orientation), gcs_crs with the WKT of the base geographic coordinate system, ud_unit. The list has class crs_parameters.
value	one of (i) character: a string accepted by GDAL, (ii) integer, a valid EPSG value (numeric), or (iii) an object of class crs.
name	element name
authority_compliant	logical; specify whether axis order should be handled compliant to the authority; if omitted, the current value is printed.

Details

The *crs functions create, get, set or replace the crs attribute of a simple feature geometry list-column. This attribute is of class crs, and is a list consisting of input (user input, e.g. "EPSG:4326" or "WGS84" or a proj4string), and wkt, an automatically generated wkt2 representation of the crs. If x is identical to the wkt2 representation, and the CRS has a name, this name is used for the input field.

Comparison of two objects of class crs uses the GDAL function OGRSpatialReference::IsSame.

In case a coordinate reference system is replaced, no transformation takes place and a warning is raised to stress this.

NA_crs_ is the crs object with missing values for input and wkt.

the $ method for crs objects retrieves named elements using the GDAL interface; named elements include SemiMajor, SemiMinor, InvFlattening, IsGeographic, units_gdal, IsVertical, WktPretty, Wkt, Name, proj4string, epsg, yx, ud_unit, and axes (this may be subject to changes in future GDAL versions).

Note that not all valid CRS have a corresponding proj4string.

ud_unit returns a valid units object or NULL if units are missing.

format.crs returns NA if the crs is missing valued, or else the name of a crs if it is different from "unknown", or else the user input if it was set, or else its "proj4string" representation;

st_axis_order can be used to get and set the axis order: TRUE indicates axes order according to the authority (e.g. EPSG:4326 defining coordinates to be latitude,longitude pairs), FALSE indicates the usual GIS (display) order (longitude,latitude). This can be useful when data are read, or have to be written, with coordinates in authority compliant order. The return value is the current state of this (FALSE, by default).

Value

If x is numeric, return crs object for EPSG:x; if x is character, return crs object for x; if x is of class sf or sfc, return its crs object.

Object of class crs, which is a list with elements input (length-1 character) and wkt (length-1 character). Elements may be NA valued; if all elements are NA the CRS is missing valued, and coordinates are assumed to relate to an arbitrary Cartesian coordinate system.

st_axis_order returns the (logical) current value if called without argument, or (invisibly) the previous value if it is being set.

Examples

```
sfc = st_sfc(st_point(c(0,0)), st_point(c(1,1)))
sf = st_sf(a = 1:2, geom = sfc)
st_crs(sf) = 4326
st_geometry(sf)
sfc = st_sfc(st_point(c(0,0)), st_point(c(1,1)))
st_crs(sfc) = 4326
sfc
sfc = st_sfc(st_point(c(0,0)), st_point(c(1,1)))
sfc |> st_set_crs(4326) |> st_transform(3857)
st_crs("EPSG:3857")$input
st_crs(3857)$proj4string
pt = st_sfc(st_point(c(0, 60)), crs = 4326)
# st_axis_order() only has effect in GDAL >= 2.5.0:
st_axis_order() # query default: FALSE means interpret pt as (longitude latitude)
st_transform(pt, 3857)[[1]]
old_value = FALSE
if (compareVersion(sf_extSoftVersion()["GDAL"], "2.5.0") >= 0)
   (old_value = st_axis_order(TRUE))
# now interpret pt as (latitude longitude), as EPSG:4326 prescribes:
st_axis_order() # query current value
st_transform(pt, 3857)[[1]]
st_axis_order(old_value) # set back to old value
```

---

st_drivers *Get GDAL drivers*

Description

Get a list of the available GDAL drivers

Usage

```
st_drivers(what = "vector", regex)
```

Arguments

what	character: "vector" or "raster", anything else will return all drivers.
regex	character; regular expression to filter the name and long_name fields on

Details

The drivers available will depend on the installation of GDAL/OGR, and can vary; the st_drivers() function shows all the drivers that are readable, and which may be written. The field vsi refers to the driver's capability to read/create datasets through the VSI*L API. See GDAL website for additional details on driver support

Value

A data.frame with driver metadata.

Examples

```
# The following driver lists depend on the GDAL setup and platform used:
st_drivers()
st_drivers("raster", "GeoT")
```

---

st_geometry *Get, set, replace or rename geometry from an sf object*

Description

Get, set, replace or rename geometry from an sf object

Usage

```
## S3 method for class 'sfc'
st_geometry(obj, ...)

st_geometry(obj, ...)

## S3 method for class 'sf'
st_geometry(obj, ...)

## S3 method for class 'sfc'
st_geometry(obj, ...)

## S3 method for class 'sfg'
st_geometry(obj, ...)
```

```
st_geometry(x) <- value

st_set_geometry(x, value)

st_drop_geometry(x, ...)

## S3 method for class 'sf'
st_drop_geometry(x, ...)

## Default S3 method:
st_drop_geometry(x, ...)
```

Arguments

obj	object of class sf or sfc
...	ignored
x	object of class data.frame or sf
value	object of class sfc, or character to set, replace, or rename the geometry of x

Details

when applied to a data.frame and when value is an object of class sfc, st_set_geometry and st_geometry<- will first check for the existence of an attribute sf_column and overwrite that, or else look for list-columns of class sfc and overwrite the first of that, or else write the geometry list-column to a column named geometry. In case value is character and x is of class sf, the "active" geometry column is set to x[[value]].

the replacement function applied to sf objects will overwrite the geometry list-column, if value is NULL, it will remove it and coerce x to a data.frame.

if x is of class sf, st_drop_geometry drops the geometry of its argument, and reclasses it accordingly; otherwise it returns x unmodified.

Value

st_geometry returns an object of class sfc, a list-column with geometries

st_geometry returns an object of class sfc. Assigning geometry to a data.frame creates an sf object, assigning it to an sf object replaces the geometry list-column.

Examples

```
df = data.frame(a = 1:2)
sfc = st_sfc(st_point(c(3,4)), st_point(c(10,11)))
st_geometry(sfc)
st_geometry(df) <- sfc
class(df)
st_geometry(df)
st_geometry(df) <- sfc # replaces
st_geometry(df) <- NULL # remove geometry, coerce to data.frame
```

```
sf <- st_set_geometry(df, sfc) # set geometry, return sf
st_set_geometry(sf, NULL) # remove geometry, coerce to data.frame
```

`st_geometry_type` *Return geometry type of an object*

Description

Return geometry type of an object, as a factor

Usage

```
st_geometry_type(x, by_geometry = TRUE)
```

Arguments

`x`	object of class sf or sfc
`by_geometry`	logical; if `TRUE`, return geometry type of each geometry, else return geometry type of the set

Value

a factor with the geometry type of each simple feature geometry in `x`, or that of the whole set

---

`st_graticule` *Compute graticules and their parameters*

Description

Compute graticules and their parameters

Usage

```
st_graticule(
  x = c(-180, -90, 180, 90),
  crs = st_crs(x),
  datum = st_crs("OGC:CRS84"),
  ...,
  lon = NULL,
  lat = NULL,
  ndiscr = 100,
  margin = 0.001
)
```

Arguments

x	object of class sf, sfc or sfg or numeric vector with bounding box given as (minx, miny, maxx, maxy).
crs	object of class crs, with the display coordinate reference system
datum	either an object of class crs with the coordinate reference system for the graticules, or NULL in which case a grid in the coordinate system of x is drawn, or NA, in which case an empty sf object is returned. If missing and x has a crs with a datum, the geographic coordinate system (datum) of x is taken.
...	ignored
lon	numeric; values in degrees East for the meridians, associated with datum
lat	numeric; values in degrees North for the parallels, associated with datum
ndiscr	integer; number of points to discretize a parallel or meridian
margin	numeric; small number to trim a longlat bounding box that touches or crosses +/-180 long or +/-90 latitude.

Value

an object of class sf with additional attributes describing the type (E: meridian, N: parallel) degree value, label, start and end coordinates and angle; see example.

Use of graticules

In cartographic visualization, the use of graticules is not advised, unless the graphical output will be used for measurement or navigation, or the direction of North is important for the interpretation of the content, or the content is intended to display distortions and artifacts created by projection. Unnecessary use of graticules only adds visual clutter but little relevant information. Use of coastlines, administrative boundaries or place names permits most viewers of the output to orient themselves better than a graticule.

Examples

```
library(sf)
if (require(maps, quietly = TRUE)) {

usa = st_as_sf(map('usa', plot = FALSE, fill = TRUE))
laea = st_crs("+proj=laea +lat_0=30 +lon_0=-95") # Lambert equal area
usa <- st_transform(usa, laea)

bb = st_bbox(usa)
bbox = st_linestring(rbind(c( bb[1],bb[2]),c( bb[3],bb[2]),
   c( bb[3],bb[4]),c( bb[1],bb[4]),c( bb[1],bb[2])))

g = st_graticule(usa)
plot(usa, xlim = 1.2 * c(-2450853.4, 2186391.9), reset = FALSE)
plot(g[1], add = TRUE, col = 'grey')
plot(bbox, add = TRUE)
points(g$x_start, g$y_start, col = 'red')
points(g$x_end, g$y_end, col = 'blue')
```

```
invisible(lapply(seq_len(nrow(g)), function(i) {
if (g$type[i] == "N" && g$x_start[i] - min(g$x_start) < 1000)
 text(g$x_start[i], g$y_start[i], labels = parse(text = g$degree_label[i]),
  srt = g$angle_start[i], pos = 2, cex = .7)
if (g$type[i] == "E" && g$y_start[i] - min(g$y_start) < 1000)
 text(g$x_start[i], g$y_start[i], labels = parse(text = g$degree_label[i]),
  srt = g$angle_start[i] - 90, pos = 1, cex = .7)
if (g$type[i] == "N" && g$x_end[i] - max(g$x_end) > -1000)
 text(g$x_end[i], g$y_end[i], labels = parse(text = g$degree_label[i]),
  srt = g$angle_end[i], pos = 4, cex = .7)
if (g$type[i] == "E" && g$y_end[i] - max(g$y_end) > -1000)
 text(g$x_end[i], g$y_end[i], labels = parse(text = g$degree_label[i]),
  srt = g$angle_end[i] - 90, pos = 3, cex = .7)
}))
plot(usa, graticule = st_crs(4326), axes = TRUE, lon = seq(-60,-130,by=-10))
}
```

`st_is` *test equality between the geometry type and a class or set of classes*

Description

test equality between the geometry type and a class or set of classes

Usage

```
st_is(x, type)
```

Arguments

`x`	object of class `sf`, `sfc` or `sfg`
`type`	character; class, or set of classes, to test against

Examples

```
st_is(st_point(0:1), "POINT")
sfc = st_sfc(st_point(0:1), st_linestring(matrix(1:6,,2)))
st_is(sfc, "POINT")
st_is(sfc, "POLYGON")
st_is(sfc, "LINESTRING")
st_is(st_sf(a = 1:2, sfc), "LINESTRING")
st_is(sfc, c("POINT", "LINESTRING"))
```

st_is_full *predicate whether a geometry is equal to a POLYGON FULL*

Description

predicate whether a geometry is equal to a POLYGON FULL

Usage

```
st_is_full(x, ...)

## S3 method for class 'sfg'
st_is_full(x, ..., is_longlat = NULL)

## S3 method for class 'sfc'
st_is_full(x, ...)

## S3 method for class 'sf'
st_is_full(x, ...)

## S3 method for class 'bbox'
st_is_full(x, ...)
```

Arguments

x	object of class sfg, sfc or sf
...	ignored, except when it contains a crs argument to inform unspecified is_longlat
is_longlat	logical; output of st_is_longlat of the parent sfc object

Value

logical, indicating whether geometries are POLYGON FULL (a spherical polygon covering the entire sphere)

st_is_longlat *Assert whether simple feature coordinates are longlat degrees*

Description

Assert whether simple feature coordinates are longlat degrees

Usage

```
st_is_longlat(x)
```

Arguments

x	object of class sf or sfc, or otherwise an object of a class that has an st_crs method returning a crs object

Value

TRUE if x has geographic coordinates, FALSE if it has projected coordinates, or NA if is.na(st_crs(x)).

---

st_jitter *jitter geometries*

Description

jitter geometries

Usage

```
st_jitter(x, amount, factor = 0.002)
```

Arguments

x	object of class sf or sfc
amount	numeric; amount of jittering applied; if missing, the amount is set to factor * the bounding box diagonal; units of coordinates.
factor	numeric; fractional amount of jittering to be applied

Details

jitters coordinates with an amount such that runif(1, -amount, amount) is added to the coordinates. x- and y-coordinates are jittered independently but all coordinates of a single geometry are jittered with the same amount, meaning that the geometry shape does not change. For longlat data, a latitude correction is made such that jittering in East and North directions are identical in distance in the center of the bounding box of x.

Examples

```
nc = st_read(system.file("gpkg/nc.gpkg", package="sf"))
pts = st_centroid(st_geometry(nc))
plot(pts)
plot(st_jitter(pts, .05), add = TRUE, col = 'red')
plot(st_geometry(nc))
plot(st_jitter(st_geometry(nc), factor = .01), add = TRUE, col = '#ff8888')
```

st_join *spatial join, spatial filter*

Description

spatial join, spatial filter

Usage

```
st_join(x, y, join, ...)

## S3 method for class 'sf'
st_join(
  x,
  y,
  join = st_intersects,
  ...,
  suffix = c(".x", ".y"),
  left = TRUE,
  largest = FALSE
)

st_filter(x, y, ...)

## S3 method for class 'sf'
st_filter(x, y, ..., .predicate = st_intersects)
```

Arguments

x	object of class sf
y	object of class sf
join	geometry predicate function with the same profile as st_intersects; see details
...	for st_join: arguments passed on to the join function or to st_intersection when largest is TRUE; for st_filter arguments passed on to the .predicate function, e.g. prepared, or a pattern for st_relate
suffix	length 2 character vector; see merge
left	logical; if TRUE return the left join, otherwise an inner join; see details. see also left_join
largest	logical; if TRUE, return x features augmented with the fields of y that have the largest overlap with each of the features of x; see https://github.com/r-spatial/sf/issues/578
.predicate	geometry predicate function with the same profile as st_intersects; see details

Details

alternative values for argument `join` are:

- st_contains_properly,
- st_contains,
- st_covered_by,
- st_covers,
- st_crosses,
- st_disjoint,
- st_equals_exact,
- st_equals,
- st_is_within_distance,
- st_nearest_feature,
- st_overlaps,
- st_touches,
- st_within,
- st_relate (which will require `pattern` to be set),
- or any user-defined function of the same profile as the above

A left join returns all records of the `x` object with `y` fields for non-matched records filled with `NA` values; an inner join returns only records that spatially match.

To replicate the results of `st_within(x, y)` you will need to use `st_join(x, y, join = "st_within", left = FALSE)`.

Value

an object of class `sf`, joined based on geometry

Examples

```
a = st_sf(a = 1:3,
 geom = st_sfc(st_point(c(1,1)), st_point(c(2,2)), st_point(c(3,3))))
b = st_sf(a = 11:14,
 geom = st_sfc(st_point(c(10,10)), st_point(c(2,2)), st_point(c(2,2)), st_point(c(3,3))))
st_join(a, b)
st_join(a, b, left = FALSE)
# two ways to aggregate y's attribute values outcome over x's geometries:
j = st_join(a, b)
aggregate(j, list(j$a.x), mean)
if (require(dplyr, quietly = TRUE)) {
 st_join(a, b) |> group_by(a.x) |> summarise(mean(a.y))
}
# example of largest = TRUE:
nc <- st_transform(st_read(system.file("shape/nc.shp", package="sf")), 2264)
gr = st_sf(
    label = apply(expand.grid(1:10, LETTERS[10:1])[,2:1], 1, paste0, collapse = " "),
```

```
    geom = st_make_grid(st_as_sfc(st_bbox(nc))))
gr$col = sf.colors(10, categorical = TRUE, alpha = .3)
# cut, to check, NA's work out:
gr = gr[-(1:30),]
nc_j <- st_join(nc, gr, largest = TRUE)
# the two datasets:
opar = par(mfrow = c(2,1), mar = rep(0,4))
plot(st_geometry(nc_j))
plot(st_geometry(gr), add = TRUE, col = gr$col)
text(st_coordinates(st_centroid(gr)), labels = gr$label)
# the joined dataset:
plot(st_geometry(nc_j), border = 'black', col = nc_j$col)
text(st_coordinates(st_centroid(nc_j)), labels = nc_j$label, cex = .8)
plot(st_geometry(gr), border = 'green', add = TRUE)
par(opar)
# st_filter keeps the geometries in x where .predicate(x,y) returns any match in y for x
st_filter(a, b)
# for an anti-join, use the union of y
st_filter(a, st_union(b), .predicate = st_disjoint)
```

`st_layers` *Return properties of layers in a datasource*

Description

Return properties of layers in a datasource

Usage

```
st_layers(dsn, options = character(0), do_count = FALSE)
```

Arguments

`dsn`	data source name (interpretation varies by driver - for some drivers, `dsn` is a file name, but may also be a folder, or contain the name and access credentials of a database)
`options`	character; driver dependent dataset open options, multiple options supported.
`do_count`	logical; if TRUE, count the features by reading them, even if their count is not reported by the driver

Value

list object of class `sf_layers` with elements

name name of the layer

geomtype list with for each layer the geometry types

features number of features (if reported; see `do_count`)

fields number of fields

crs list with for each layer the `crs` object

st_line_project_point *Project point on linestring, interpolate along a linestring*

Description

Project point on linestring, interpolate along a linestring

Usage

```
st_line_project(line, point, normalized = FALSE)

st_line_interpolate(line, dist, normalized = FALSE)
```

Arguments

line	object of class sfc with LINESTRING geometry
point	object of class sfc with POINT geometry
normalized	logical; if TRUE, use or return distance normalised to 0-1
dist	numeric or units, vector with distance value(s), in units of the coordinates

Details

arguments line, point and dist are recycled to common length when needed

Value

st_line_project returns the distance(s) of point(s) along line(s), when projected on the line(s)

st_line_interpolate returns the point(s) at dist(s), when measured along (interpolated on) the line(s)

Examples

```
st_line_project(st_as_sfc("LINESTRING (0 0, 10 10)"), st_as_sfc(c("POINT (0 0)", "POINT (5 5)")))
st_line_project(st_as_sfc("LINESTRING (0 0, 10 10)"), st_as_sfc("POINT (5 5)"), TRUE)
st_line_interpolate(st_as_sfc("LINESTRING (0 0, 1 1)"), 1)
st_line_interpolate(st_as_sfc("LINESTRING (0 0, 1 1)"), 1, TRUE)
# https://github.com/r-spatial/sf/issues/2542; use for geographic coordinates:
l1 <- st_as_sfc("LINESTRING (10.1 50.1, 10.2 50.2)", crs = 'OGC:CRS84')
dists = units::set_units(seq(0, sqrt(2)/10, length.out = 5), degrees)
st_line_interpolate(l1, dists)
```

st_line_sample *Sample points on a linear geometry*

Description

Sample points on a linear geometry

Usage

```
st_line_sample(x, n, density, type = "regular", sample = NULL)
```

Arguments

x	object of class sf, sfc or sfg
n	integer; number of points to choose per geometry; if missing, n will be computed as round(density * st_length(geom)).
density	numeric; density (points per distance unit) of the sampling, possibly a vector of length equal to the number of features (otherwise recycled); density may be of class units.
type	character; indicate the sampling type, either "regular" or "random"
sample	numeric; a vector of numbers between 0 and 1 indicating the points to sample - if defined sample overrules n, density and type.

Examples

```
ls = st_sfc(st_linestring(rbind(c(0,0),c(0,1))),
 st_linestring(rbind(c(0,0),c(10,0))))
st_line_sample(ls, density = 1)
ls = st_sfc(st_linestring(rbind(c(0,0),c(0,1))),
 st_linestring(rbind(c(0,0),c(.1,0))), crs = 4326)
try(st_line_sample(ls, density = 1/1000)) # error
st_line_sample(st_transform(ls, 3857), n = 5) # five points for each line
st_line_sample(st_transform(ls, 3857), n = c(1, 3)) # one and three points
st_line_sample(st_transform(ls, 3857), density = 1/1000) # one per km
st_line_sample(st_transform(ls, 3857), density = c(1/1000, 1/10000)) # one per km, one per 10 km
st_line_sample(st_transform(ls, 3857), density = units::set_units(1, 1/km)) # one per km
# five equidistant points including start and end:
st_line_sample(st_transform(ls, 3857), sample = c(0, 0.25, 0.5, 0.75, 1))
```

st_m_range *Return 'm' range of a simple feature or simple feature set*

Description

Return 'm' range of a simple feature or simple feature set

Usage

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

st_m_range(obj, ...)

## S3 method for class 'POINT'
st_m_range(obj, ...)

## S3 method for class 'MULTIPOINT'
st_m_range(obj, ...)

## S3 method for class 'LINESTRING'
st_m_range(obj, ...)

## S3 method for class 'POLYGON'
st_m_range(obj, ...)

## S3 method for class 'MULTILINESTRING'
st_m_range(obj, ...)

## S3 method for class 'MULTIPOLYGON'
st_m_range(obj, ...)

## S3 method for class 'GEOMETRYCOLLECTION'
st_m_range(obj, ...)

## S3 method for class 'MULTISURFACE'
st_m_range(obj, ...)

## S3 method for class 'MULTICURVE'
st_m_range(obj, ...)

## S3 method for class 'CURVEPOLYGON'
st_m_range(obj, ...)

## S3 method for class 'COMPOUNDCURVE'
st_m_range(obj, ...)
```

```
## S3 method for class 'POLYHEDRALSURFACE'
st_m_range(obj, ...)

## S3 method for class 'TIN'
st_m_range(obj, ...)

## S3 method for class 'TRIANGLE'
st_m_range(obj, ...)

## S3 method for class 'CIRCULARSTRING'
st_m_range(obj, ...)

## S3 method for class 'sfc'
st_m_range(obj, ...)

## S3 method for class 'sf'
st_m_range(obj, ...)

## S3 method for class 'numeric'
st_m_range(obj, ..., crs = NA_crs_)

NA_m_range_
```

Arguments

x	object of class m_range
obj	object to compute the m range from
...	ignored
crs	object of class crs, or argument to st_crs, specifying the CRS of this bounding box.

Details

NA_m_range_ represents the missing value for a m_range object

Value

a numeric vector of length two, with mmin and mmax values; if obj is of class sf or sfc the object if obj is of class sf or sfc the object returned has a class m_range

Examples

```
a = st_sf(a = 1:2, geom = st_sfc(st_point(0:3), st_point(1:4)), crs = 4326)
st_m_range(a)
st_m_range(c(mmin = 16.1, mmax = 16.6), crs = st_crs(4326))
```

st_make_grid *Create a regular tesselation over the bounding box of an sf or sfc object*

Description

Create a square or hexagonal grid covering the bounding box of the geometry of an sf or sfc object

Usage

```
st_make_grid(
  x,
  cellsize = c(diff(st_bbox(x)[c(1, 3)]), diff(st_bbox(x)[c(2, 4)]))/n,
  offset = st_bbox(x)[c("xmin", "ymin")],
  n = c(10, 10),
  crs = if (missing(x)) NA_crs_ else st_crs(x),
  what = "polygons",
  square = TRUE,
  flat_topped = FALSE
)
```

Arguments

x	object of class sf or sfc
cellsize	numeric of length 1 or 2 with target cellsize: for square or rectangular cells the width and height, for hexagonal cells the distance between opposite edges (edge length is cellsize/sqrt(3)). A length units object can be passed, or an area unit object with area size of the square or hexagonal cell.
offset	numeric of length 2; lower left corner coordinates (x, y) of the grid
n	integer of length 1 or 2, number of grid cells in x and y direction (columns, rows)
crs	object of class crs; coordinate reference system of the target grid in case argument x is missing, if x is not missing, its crs is inherited.
what	character; one of: "polygons", "corners", or "centers"
square	logical; if FALSE, create hexagonal grid
flat_topped	logical; if TRUE generate flat topped hexagons, else generate pointy topped

Value

Object of class sfc (simple feature geometry list column) with, depending on what and square, square or hexagonal polygons, corner points of these polygons, or center points of these polygons.

Examples

```
plot(st_make_grid(what = "centers"), axes = TRUE)
plot(st_make_grid(what = "corners"), add = TRUE, col = 'green', pch=3)
sfc = st_sfc(st_polygon(list(rbind(c(0,0), c(1,0), c(1,1), c(0,0)))))
plot(st_make_grid(sfc, cellsize = .1, square = FALSE))
plot(sfc, add = TRUE)
# non-default offset:
plot(st_make_grid(sfc, cellsize = .1, square = FALSE, offset = c(0, .05 / (sqrt(3)/2))))
plot(sfc, add = TRUE)
nc = st_read(system.file("shape/nc.shp", package="sf"))
g = st_make_grid(nc)
plot(g)
plot(st_geometry(nc), add = TRUE)
# g[nc] selects cells that intersect with nc:
plot(g[nc], col = '#ff000088', add = TRUE)
```

---

st_nearest_feature *get index of nearest feature*

Description

get index of nearest feature

Usage

```
st_nearest_feature(
  x,
  y,
  ...,
  check_crs = TRUE,
  longlat = isTRUE(st_is_longlat(x))
)
```

Arguments

x	object of class sfg, sfc or sf
y	object of class sfg, sfc or sf; if missing, features in x will be compared to all remaining features in x.
...	ignored
check_crs	logical; should x and y be checked for CRS equality?
longlat	logical; does x have ellipsoidal coordinates?

Value

for each feature (geometry) in x the index of the nearest feature (geometry) in set y, or in the remaining set of x if y is missing; empty geometries result in NA indexes

See Also

st_nearest_points for finding the nearest points for pairs of feature geometries

Examples

```
ls1 = st_linestring(rbind(c(0,0), c(1,0)))
ls2 = st_linestring(rbind(c(0,0.1), c(1,0.1)))
ls3 = st_linestring(rbind(c(0,1), c(1,1)))
(l = st_sfc(ls1, ls2, ls3))

p1 = st_point(c(0.1, -0.1))
p2 = st_point(c(0.1, 0.11))
p3 = st_point(c(0.1, 0.09))
p4 = st_point(c(0.1, 0.9))

(p = st_sfc(p1, p2, p3, p4))
try(st_nearest_feature(p, l))
try(st_nearest_points(p, l[st_nearest_feature(p,l)], pairwise = TRUE))

r = sqrt(2)/10
b1 = st_buffer(st_point(c(.1,.1)), r)
b2 = st_buffer(st_point(c(.9,.9)), r)
b3 = st_buffer(st_point(c(.9,.1)), r)
circles = st_sfc(b1, b2, b3)
plot(circles, col = NA, border = 2:4)
pts = st_sfc(st_point(c(.3,.1)), st_point(c(.6,.2)), st_point(c(.6,.6)), st_point(c(.4,.8)))
plot(pts, add = TRUE, col = 1)
# draw points to nearest circle:
nearest = try(st_nearest_feature(pts, circles))
if (inherits(nearest, "try-error")) # GEOS 3.6.1 not available
  nearest = c(1, 3, 2, 2)
ls = st_nearest_points(pts, circles[nearest], pairwise = TRUE)
plot(ls, col = 5:8, add = TRUE)
# compute distance between pairs of nearest features:
st_distance(pts, circles[nearest], by_element = TRUE)
```

---

st_nearest_points *get nearest points between pairs of geometries*

Description

get nearest points between pairs of geometries

Usage

```
st_nearest_points(x, y, ..., by_element = FALSE)

## S3 method for class 'sfc'
st_nearest_points(x, y, ..., pairwise = by_element, by_element = FALSE)
```

```
## S3 method for class 'sfg'
st_nearest_points(x, y, ...)

## S3 method for class 'sf'
st_nearest_points(x, y, ...)
```

Arguments

x	object of class sfg, sfc or sf
y	object of class sfg, sfc or sf; needs to have the same number of geometries of x when by_element=TRUE
...	ignored
by_element	logical; if FALSE (default) return nearest points between all possible pairs, if TRUE, return nearest points between row-wise x-y pairs.
pairwise	logical; deprecated in favour of by_element

Details

in case x lies inside y, when using S2, the end points are on polygon boundaries, when using GEOS the end point are identical to x.

Value

an sfc object with all two-point LINESTRING geometries of point pairs from the first to the second geometry, of length x * y if by_element=FALSE (with y cycling fastest), or lf length length(x) when by_element=TRUE. See examples for ideas how to convert these to POINT geometries.

See Also

st_nearest_feature for finding the nearest feature

Examples

```
r = sqrt(2)/10
pt1 = st_point(c(.1,.1))
pt2 = st_point(c(.9,.9))
pt3 = st_point(c(.9,.1))
b1 = st_buffer(pt1, r)
b2 = st_buffer(pt2, r)
b3 = st_buffer(pt3, r)
(ls0 = st_nearest_points(b1, b2)) # sfg
(ls = st_nearest_points(st_sfc(b1), st_sfc(b2, b3))) # sfc
plot(b1, xlim = c(-.2,1.2), ylim = c(-.2,1.2), col = NA, border = 'green')
plot(st_sfc(b2, b3), add = TRUE, col = NA, border = 'blue')
plot(ls, add = TRUE, col = 'red')

nc = st_read(system.file("gpkg/nc.gpkg", package="sf"))
plot(st_geometry(nc))
ls = st_nearest_points(nc[1,], nc)
```

```
plot(ls, col = 'red', add = TRUE)
pts = st_cast(ls, "POINT") # gives all start & end points
# starting, "from" points, corresponding to x:
plot(pts[seq(1, 200, 2)], add = TRUE, col = 'blue')
# ending, "to" points, corresponding to y:
plot(pts[seq(2, 200, 2)], add = TRUE, col = 'green')
```

`st_normalize` *Normalize simple features*

Description

`st_normalize` transforms the coordinates in the input feature to fall between 0 and 1. By default the current domain is set to the bounding box of the input, but other domains can be used as well

Usage

```
st_normalize(x, domain = st_bbox(x), ...)
```

Arguments

`x`	object of class sf, sfc or sfg
`domain`	The domain `x` should be normalized from as a length 4 vector of the form `c(xmin, ymin, xmax, ymax)`. Defaults to the bounding box of `x`
`...`	ignored

Examples

```
p1 = st_point(c(7,52))
st_normalize(p1, domain = c(0, 0, 10, 100))

p2 = st_point(c(-30,20))
sfc = st_sfc(p1, p2, crs = 4326)
sfc
sfc_norm <- st_normalize(sfc)
st_bbox(sfc_norm)
```

st_precision *Get precision*

Description

Get precision

Set precision

Usage

```
st_precision(x)

st_set_precision(x, precision)

st_precision(x) <- value
```

Arguments

x	object of class sfc or sf
precision	numeric, or object of class units with distance units (but see details); see st_as_binary for how to do this.
value	precision value

Details

If precision is a units object, the object on which we set precision must have a coordinate reference system with compatible distance units.

Setting a precision has no direct effect on coordinates of geometries, but merely set an attribute tag to an sfc object. The effect takes place in st_as_binary or, more precise, in the C++ function CPL_write_wkb, where simple feature geometries are being serialized to well-known-binary (WKB). This happens always when routines are called in GEOS library (geometrical operations or predicates), for writing geometries using st_write or write_sf, st_make_valid in package lwgeom; also aggregate and summarise by default union geometries, which calls a GEOS library function. Routines in these libraries receive rounded coordinates, and possibly return results based on them. st_as_binary contains an example of a roundtrip of sfc geometries through WKB, in order to see the rounding happening to R data.

The reason to support precision is that geometrical operations in GEOS or liblwgeom may work better at reduced precision. For writing data from R to external resources it is harder to think of a good reason to limiting precision.

See Also

st_as_binary for an explanation of what setting precision does, and the examples therein.

Examples

```
x <- st_sfc(st_point(c(pi, pi)))
st_precision(x)
st_precision(x) <- 0.01
st_precision(x)
```

---

st_read *Read simple features or layers from file or database*

Description

Read simple features from file or database, or retrieve layer names and their geometry type(s)

Read PostGIS table directly through DBI and RPostgreSQL interface, converting Well-Know Binary geometries to sfc

Usage

```
st_read(dsn, layer, ...)

## S3 method for class 'character'
st_read(
  dsn,
  layer,
  ...,
  query = NA,
  options = NULL,
  quiet = FALSE,
  geometry_column = 1L,
  type = 0,
  promote_to_multi = TRUE,
  stringsAsFactors = sf_stringsAsFactors(),
  int64_as_string = FALSE,
  check_ring_dir = FALSE,
  fid_column_name = character(0),
  drivers = character(0),
  wkt_filter = character(0),
  optional = FALSE,
  use_stream = default_st_read_use_stream()
)

read_sf(..., quiet = TRUE, stringsAsFactors = FALSE, as_tibble = TRUE)

## S3 method for class 'DBIObject'
st_read(
  dsn = NULL,
  layer = NULL,
```

```
  query = NULL,
  EWKB = TRUE,
  quiet = TRUE,
  as_tibble = FALSE,
  geometry_column = NULL,
  ...
)
```

Arguments

dsn	data source name (interpretation varies by driver - for some drivers, dsn is a file name, but may also be a folder, or contain the name and access credentials of a database); in case of GeoJSON, dsn may be the character string holding the geojson data. It can also be an open database connection.
layer	layer name (varies by driver, may be a file name without extension); in case layer is missing, st_read will read the first layer of dsn, give a warning and (unless quiet = TRUE) print a message when there are multiple layers, or give an error if there are no layers in dsn. If dsn is a database connection, then layer can be a table name or a database identifier (see Id). It is also possible to omit layer and rather use the query argument.
...	parameter(s) passed on to st_as_sf
query	SQL query to select records; see details
options	character; driver dependent dataset open options, multiple options supported. For possible values, see the "Open options" section of the GDAL documentation of the corresponding driver, and https://github.com/r-spatial/sf/issues/1157 for an example.
quiet	logical; suppress info on name, driver, size and spatial reference, or signaling no or multiple layers
geometry_column	integer or character; in case of multiple geometry fields, which one to take?
type	integer; ISO number of desired simple feature type; see details. If left zero, and promote_to_multi is TRUE, in case of mixed feature geometry types, conversion to the highest numeric type value found will be attempted. A vector with different values for each geometry column can be given.
promote_to_multi	logical; in case of a mix of Point and MultiPoint, or of LineString and MultiLineString, or of Polygon and MultiPolygon, convert all to the Multi variety; defaults to TRUE
stringsAsFactors	logical; should character vectors be converted to factors? Default for read_sf or R version >= 4.1.0 is FALSE, for st_read and R version < 4.1.0 equal to default.stringsAsFactors()
int64_as_string	logical; if TRUE, Int64 attributes are returned as string; if FALSE, they are returned as double and a warning is given when precision is lost (i.e., values are larger than 2^53).

check_ring_dir	logical; if TRUE, polygon ring directions are checked and if necessary corrected (when seen from above: exterior ring counter clockwise, holes clockwise)
fid_column_name	character; name of column to write feature IDs to; defaults to not doing this
drivers	character; limited set of driver short names to be tried (default: try all)
wkt_filter	character; WKT representation of a spatial filter (may be used as bounding box, selecting overlapping geometries); see examples
optional	logical; passed to as.data.frame; always TRUE when as_tibble is TRUE
use_stream	Use TRUE to use the experimental columnar interface introduced in GDAL 3.6.
as_tibble	logical; should the returned table be of class tibble or data.frame?
EWKB	logical; is the WKB of type EWKB? if missing, defaults to TRUE

Details

for geometry_column, see also https://gdal.org/en/latest/development/rfc/rfc41_multiple_geometry_fields.html

for values for type see https://en.wikipedia.org/wiki/Well-known_text_representation_of_geometry#Well-known_binary, but note that not every target value may lead to successful conversion. The typical conversion from POLYGON (3) to MULTIPOLYGON (6) should work; the other way around (type=3), secondary rings from MULTIPOLYGONS may be dropped without warnings. promote_to_multi is handled on a per-geometry column basis; type may be specified for each geometry column.

Note that stray files in data source directories (such as *.dbf) may lead to spurious errors that accompanying *.shp are missing.

In case of problems reading shapefiles from USB drives on OSX, please see https://github.com/r-spatial/sf/issues/252. Reading shapefiles (or other data sources) directly from zip files can be done by prepending the path with /vsizip/. This is part of the GDAL Virtual File Systems interface that also supports .gz, curl, and other operations, including chaining; see https://gdal.org/en/latest/user/virtual_file_systems.html for a complete description and examples.

For query with a character dsn the query text is handed to 'ExecuteSQL' on the GDAL/OGR data set and will result in the creation of a new layer (and layer is ignored). See 'OGRSQL' https://gdal.org/en/latest/user/ogr_sql_dialect.html for details. Please note that the 'FID' special field is driver-dependent, and may be either 0-based (e.g. ESRI Shapefile), 1-based (e.g. MapInfo) or arbitrary (e.g. OSM). Other features of OGRSQL are also likely to be driver dependent. The available layer names may be obtained with st_layers. Care will be required to properly escape the use of some layer names.

read_sf and write_sf are aliases for st_read and st_write, respectively, with some modified default arguments. read_sf and write_sf are quiet by default: they do not print information about the data source. read_sf returns an sf-tibble rather than an sf-data.frame. write_sf delete layers by default: it overwrites existing files without asking or warning.

if table is not given but query is, the spatial reference system (crs) of the table queried is only available in case it has been stored into each geometry record (e.g., by PostGIS, when using EWKB)

The function will automatically find the geometry type columns for drivers that support it. For the other drivers, it will try to cast all the character columns, which can be slow for very wide tables.

Value

object of class sf when a layer was successfully read; in case argument `layer` is missing and data source `dsn` does not contain a single layer, an object of class `sf_layers` is returned with the layer names, each with their geometry type(s). Note that the number of layers may also be zero.

Note

The use of `system.file` in examples make sure that examples run regardless where R is installed: typical users will not use `system.file` but give the file name directly, either with full path or relative to the current working directory (see getwd). "Shapefiles" consist of several files with the same basename that reside in the same directory, only one of them having extension `.shp`.

See Also

st_layers, st_drivers

Examples

```
nc = st_read(system.file("shape/nc.shp", package="sf"))
summary(nc) # note that AREA was computed using Euclidian area on lon/lat degrees

## only three fields by select clause
## only two features by where clause
nc_sql = st_read(system.file("shape/nc.shp", package="sf"),
                     query = "SELECT NAME, SID74, FIPS FROM \"nc\" WHERE BIR74 > 20000")
## Not run:
  library(sp)
  example(meuse, ask = FALSE, echo = FALSE)
  try(st_write(st_as_sf(meuse), "PG:dbname=postgis", "meuse",
       layer_options = "OVERWRITE=true"))
  try(st_meuse <- st_read("PG:dbname=postgis", "meuse"))
  if (exists("st_meuse"))
    summary(st_meuse)

## End(Not run)

## Not run:
## note that we need special escaping of layer  within single quotes (nc.gpkg)
## and that geom needs to be included in the select, otherwise we don't detect it
layer <- st_layers(system.file("gpkg/nc.gpkg", package = "sf"))$name[1]
nc_gpkg_sql = st_read(system.file("gpkg/nc.gpkg", package = "sf"),
  query = sprintf("SELECT NAME, SID74, FIPS, geom  FROM \"%s\" WHERE BIR74 > 20000", layer))

## End(Not run)
# spatial filter, as wkt:
wkt = st_as_text(st_geometry(nc[1,]))
# filter by (bbox overlaps of) first feature geometry:
st_read(system.file("gpkg/nc.gpkg", package="sf"), wkt_filter = wkt)
# read geojson from string:
geojson_txt <- paste("{\"type\":\"MultiPoint\",\"coordinates\":",
   "[[3.2,4],[3,4.6],[3.8,4.4],[3.5,3.8],[3.4,3.6],[3.9,4.5]]}")
```

```
x = st_read(geojson_txt)
x
## Not run:
library(RPostgreSQL)
try(conn <- dbConnect(PostgreSQL(), dbname = "postgis"))
if (exists("conn") && !inherits(conn, "try-error")) {
  x = st_read(conn, "meuse", query = "select * from meuse limit 3;")
  x = st_read(conn, table = "public.meuse")
  print(st_crs(x)) # SRID resolved by the database, not by GDAL!
  dbDisconnect(conn)
 }

## End(Not run)
```

`st_relate` *Compute DE9-IM relation between pairs of geometries, or match it to a given pattern*

Description

Compute DE9-IM relation between pairs of geometries, or match it to a given pattern

Usage

```
st_relate(x, y, pattern = NA_character_, sparse = !is.na(pattern), ...)
```

Arguments

`x`	object of class `sf`, `sfc` or `sfg`
`y`	object of class `sf`, `sfc` or `sfg`
`pattern`	character; define the pattern to match to, see details.
`sparse`	logical; should a sparse matrix be returned (`TRUE`) or a dense matrix?
`...`	may be used to specify `by_element=TRUE` to return a vector with element-wise relations or matches

Value

In case `pattern` is not given, `st_relate` returns a dense `character` matrix; element `[i,j]` has nine characters, referring to the DE9-IM relationship between `x[i]` and `y[j]`, encoded as IxIy,IxBy,IxEy,BxIy,BxBy,BxEy,ExIy,E where I refers to interior, B to boundary, and E to exterior, and e.g. BxIy the dimensionality of the intersection of the the boundary of `x[i]` and the interior of `y[j]`, which is one of: 0, 1, 2, or F; digits denoting dimensionality of intersection, F denoting no intersection. When `pattern` is given, a dense logical matrix or sparse index list returned with matches to the given pattern; see st_intersects for a description of the returned matrix or list. See also https://en.wikipedia.org/wiki/DE-9IM for further explanation.

Examples

```
p1 = st_point(c(0,0))
p2 = st_point(c(2,2))
pol1 = st_polygon(list(rbind(c(0,0),c(1,0),c(1,1),c(0,1),c(0,0)))) - 0.5
pol2 = pol1 + 1
pol3 = pol1 + 2
st_relate(st_sfc(p1, p2), st_sfc(pol1, pol2, pol3))
sfc = st_sfc(st_point(c(0,0)), st_point(c(3,3)))
grd = st_make_grid(sfc, n = c(3,3))
st_intersects(grd)
st_relate(grd, pattern = "****1****") # sides, not corners, internals
st_relate(grd, pattern = "****0****") # only corners touch
st_rook = function(a, b = a) st_relate(a, b, pattern = "F***1****")
st_rook(grd)
# queen neighbours, see \url{https://github.com/r-spatial/sf/issues/234#issuecomment-300511129}
st_queen <- function(a, b = a) st_relate(a, b, pattern = "F***T****")
```

---

st_sample *sample points on or in (sets of) spatial features*

Description

Sample points on or in (sets of) spatial features. By default, returns a pre-specified number of points that is equal to `size` (if `type = "random"` and `exact = TRUE`) or an approximation of `size` otherwise. `spatstat` methods are interfaced and do not use the `size` argument, see examples.

Usage

```
st_sample(x, size, ...)

## S3 method for class 'sf'
st_sample(x, size, ...)

## S3 method for class 'sfc'
st_sample(
  x,
  size,
  ...,
  type = "random",
  exact = TRUE,
  warn_if_not_integer = TRUE,
  by_polygon = FALSE,
  progress = FALSE,
  force = FALSE
)

## S3 method for class 'sfg'
st_sample(x, size, ...)
```

```
## S3 method for class 'bbox'
st_sample(
  x,
  size,
  ...,
  great_circles = FALSE,
  segments = units::set_units(2, "degree", mode = "standard")
)
```

Arguments

x	object of class sf or sfc
size	sample size(s) requested; either total size, or a numeric vector with sample sizes for each feature geometry. When sampling polygons, the returned sampling size may differ from the requested size, as the bounding box is sampled, and sampled points intersecting the polygon are returned.
...	passed on to sample for multipoint sampling, or to spatstat functions for spatstat sampling types (see details)
type	character; indicates the spatial sampling type; one of random, hexagonal (triangular really), regular, Fibonacci, or one of the spatstat methods such as Thomas for calling spatstat.random::rThomas (see Details).
exact	logical; should the length of output be exactly
warn_if_not_integer	logical; if FALSE then no warning is emitted if size is not an integer
by_polygon	logical; for MULTIPOLYGON geometries, should the effort be split by POLYGON? See https://github.com/r-spatial/sf/issues/1480 the same as specified by size? TRUE by default. Only applies to polygons, and when type = "random".
progress	logical; if TRUE show progress bar (only if size is a vector).
force	logical; if TRUE continue when the sampled bounding box area is more than 1e4 times the area of interest, else (default) stop with an error. If this error is not justified, try setting oriented=TRUE, see details.
great_circles	logical; if TRUE, great circle arcs are used to connect the bounding box vertices, if FALSE parallels (graticules)
segments	units, or numeric (degrees); segment sizes for segmenting a bounding box polygon if great_circles is FALSE

Details

The function is vectorised: it samples size points across all geometries in the object if size is a single number, or the specified number of points in each feature if size is a vector of integers equal in length to the geometry of x.

if x has dimension 2 (polygons) and geographical coordinates (long/lat), uniform random sampling on the sphere is applied, see e.g. https://mathworld.wolfram.com/SpherePointPicking.html.

For regular or hexagonal sampling of polygons, the resulting size is only an approximation.

As parameter called `offset` can be passed to control ("fix") regular or hexagonal sampling: for polygons a length 2 numeric vector (by default: a random point from `st_bbox(x)`); for lines use a number like `runif(1)`.

Fibonacci sampling see: Alvaro Gonzalez, 2010. Measurement of Areas on a Sphere Using Fibonacci and Latitude-Longitude Lattices. Mathematical Geosciences 42(1), p. 49-64

For regular sampling on the sphere, see also `geosphere::regularCoordinates`.

Sampling methods from package `spatstat` are interfaced (see examples), and need their own parameters to be set. For instance, to use `spatstat.random::rThomas()`, set `type = "Thomas"`.

For sampling polygons one can specify `oriented=TRUE` to make sure that polygons larger than half the globe are not reverted, e.g. when specifying a polygon from a bounding box of a global dataset. The `st_sample` method for bbox does this by default.

Value

an `sfc` object containing the sampled `POINT` geometries

Examples

```
nc = st_read(system.file("shape/nc.shp", package="sf"))
p1 = st_sample(nc[1:3, ], 6)
p2 = st_sample(nc[1:3, ], 1:3)
plot(st_geometry(nc)[1:3])
plot(p1, add = TRUE)
plot(p2, add = TRUE, pch = 2)
x = st_sfc(st_polygon(list(rbind(c(0,0),c(90,0),c(90,90),c(0,90),c(0,0)))), crs = st_crs(4326))
plot(x, axes = TRUE, graticule = TRUE)
if (compareVersion(sf_extSoftVersion()["proj.4"], "4.9.0") >= 0)
  plot(p <- st_sample(x, 1000), add = TRUE)
if (require(lwgeom, quietly = TRUE)) { # for st_segmentize()
  x2 = st_transform(st_segmentize(x, 1e4), st_crs("+proj=ortho +lat_0=30 +lon_0=45"))
  g = st_transform(st_graticule(), st_crs("+proj=ortho +lat_0=30 +lon_0=45"))
  plot(x2, graticule = g)
  if (compareVersion(sf_extSoftVersion()["proj.4"], "4.9.0") >= 0) {
    p2 = st_transform(p, st_crs("+proj=ortho +lat_0=30 +lon_0=45"))
    plot(p2, add = TRUE)
  }
}
x = st_sfc(st_polygon(list(rbind(c(0,0),c(90,0),c(90,10),c(0,90),c(0,0))))) # NOT long/lat:
plot(x)
p_exact = st_sample(x, 1000, exact = TRUE)
p_not_exact = st_sample(x, 1000, exact = FALSE)
length(p_exact); length(p_not_exact)
plot(st_sample(x, 1000), add = TRUE)
x = st_sfc(st_polygon(list(rbind(c(-180,-90),c(180,-90),c(180,90),c(-180,90),c(-180,-90)))),
 crs=st_crs(4326))
# FIXME:
#if (compareVersion(sf_extSoftVersion()["proj.4"], "4.9.0") >= 0) {
#  p = st_sample(x, 1000)
#  st_sample(p, 3)
#}
```

```
# hexagonal:
sfc = st_sfc(st_polygon(list(rbind(c(0,0), c(1,0), c(1,1), c(0,0)))))
plot(sfc)
h = st_sample(sfc, 100, type = "hexagonal")
h1 = st_sample(sfc, 100, type = "hexagonal")
plot(h, add = TRUE)
plot(h1, col = 'red', add = TRUE)
c(length(h), length(h1)) # approximate!
pt = st_multipoint(matrix(1:20,,2))
ls = st_sfc(st_linestring(rbind(c(0,0),c(0,1))),
 st_linestring(rbind(c(0,0),c(.1,0))),
 st_linestring(rbind(c(0,1),c(.1,1))),
 st_linestring(rbind(c(2,2),c(2,2.00001))))
st_sample(ls, 80)
plot(st_sample(ls, 80))
# spatstat example:
if (require(spatstat.random)) {
  x <- sf::st_sfc(sf::st_polygon(list(rbind(c(0, 0), c(10, 0), c(10, 10), c(0, 0)))))
  # for spatstat.random::rThomas(), set type = "Thomas":
  pts <- st_sample(x, kappa = 1, mu = 10, scale = 0.1, type = "Thomas")
}
bbox = st_bbox(
c(xmin = 0, xmax = 40, ymax = 70, ymin = 60),
 crs = st_crs('OGC:CRS84')
)
set.seed(13531)
s1 = st_sample(bbox, 400)
st_bbox(s1) # within bbox
s2 = st_sample(bbox, 400, great_circles = TRUE)
st_bbox(s2) # outside bbox
```

`st_shift_longitude` *Shift or re-center geographical coordinates for a Pacific view*

Description

All longitudes < 0 are added to 360, to avoid for instance parts of Alaska being represented on the far left and right of a plot because they have values straddling 180 degrees. In general, using a projected coordinate reference system is to be preferred, but this method permits a geographical coordinate reference system to be used. This is the sf equivalent of recenter in the sp package and `ST_ShiftLongitude` in PostGIS.

Usage

```
st_shift_longitude(x)

## S3 method for class 'sfc'
st_shift_longitude(x, ...)

## S3 method for class 'sf'
st_shift_longitude(x, ...)
```

Arguments

x	object of class sf or sfc
...	ignored

Examples

```
## sfc
pt1 = st_point(c(-170, 50))
pt2 = st_point(c(170, 50))
(sfc = st_sfc(pt1, pt2))
sfc = st_set_crs(sfc, 4326)
st_shift_longitude(sfc)

## sf
d = st_as_sf(data.frame(id = 1:2, geometry = sfc))
st_shift_longitude(d)
```

---

st_transform *Transform or convert coordinates of simple feature*

Description

Transform or convert coordinates of simple feature

Usage

```
st_can_transform(src, dst)

st_transform(x, crs, ...)

## S3 method for class 'sfc'
st_transform(
  x,
  crs = st_crs(x),
  ...,
  aoi = numeric(0),
  pipeline = character(0),
  reverse = FALSE,
  desired_accuracy = -1,
  allow_ballpark = TRUE,
  partial = TRUE,
  check = FALSE
)

## S3 method for class 'sf'
st_transform(x, crs = st_crs(x), ...)
```

```
## S3 method for class 'sfg'
st_transform(x, crs = st_crs(x), ...)

## S3 method for class 'bbox'
st_transform(x, crs, ..., densify = 21)

st_wrap_dateline(x, options, quiet)

## S3 method for class 'sfc'
st_wrap_dateline(x, options = "WRAPDATELINE=YES", quiet = TRUE)

## S3 method for class 'sf'
st_wrap_dateline(x, options = "WRAPDATELINE=YES", quiet = TRUE)

## S3 method for class 'sfg'
st_wrap_dateline(x, options = "WRAPDATELINE=YES", quiet = TRUE)

sf_proj_info(type = "proj", path)
```

Arguments

src	source crs
dst	destination crs
x	object of class sf, sfc or sfg
crs	target coordinate reference system: object of class crs, or input string for st_crs
...	for the sfc method ignored, for other methods passed on to the sfc method
aoi	area of interest, in degrees: WestLongitude, SouthLatitude, EastLongitude, NorthLatitude
pipeline	character; coordinate operation pipeline, for overriding the default operation
reverse	boolean; has only an effect when pipeline is defined: if TRUE, the inverse operation of the pipeline is applied
desired_accuracy	numeric; Only coordinate operations that offer an accuracy of at least the one specified will be considered; a negative value disables this feature (requires GDAL >= 3.3)
allow_ballpark	logical; are ballpark (low accuracy) transformations allowed? (requires GDAL >= 3.3)
partial	logical; allow for partial projection, if not all points of a geometry can be projected (corresponds to setting environment variable OGR_ENABLE_PARTIAL_REPROJECTION to TRUE)
check	logical; if TRUE, perform a sanity check on resulting polygons
densify	integer, number of points for discretizing lines between bounding box corner points; see Details
options	character; should have "WRAPDATELINE=YES" to function; another parameter that is used is "DATELINEOFFSET=10" (where 10 is the default value)

quiet	logical; print options after they have been parsed?
type	character; one of have_datum_files, proj, ellps, datum, units, path, or prime_meridians; see Details.
path	character; PROJ search path to be set

Details

st_can_transform returns a boolean indicating whether coordinates with CRS src can be transformed into CRS dst

Transforms coordinates of object to new projection. Features that cannot be transformed are returned as empty geometries. Transforms using the pipeline= argument may fail if there is ambiguity in the axis order of the specified coordinate reference system; if you need the traditional GIS order, use "OGC:CRS84", not "EPSG:4326". Extra care is needed with the ESRI Shapefile format, because WKT1 does not store axis order unambiguously.

The st_transform method for sfg objects assumes that the CRS of the object is available as an attribute of that name.

the method for bbox objects densifies lines for geographic coordinates along Cartesian lines, not great circle arcs

For a discussion of using options, see https://github.com/r-spatial/sf/issues/280 and https://github.com/r-spatial/sf/issues/1983

sf_proj_info lists the available projections, ellipses, datums, units, or data search path of the PROJ library when type is equal to proj, ellps, datum, units or path; when type equals have_datum_files a boolean is returned indicating whether datum files are installed and accessible (checking for conus). path returns the PROJ_INFO.searchpath field directly, as a single string with path separaters (: or ;).

for PROJ >= 6, sf_proj_info does not provide option type = "datums". PROJ < 6 does not provide the option type = "prime_meridians".

for PROJ >= 7.1.0, the "units" query of sf_proj_info returns the to_meter variable as numeric, previous versions return a character vector containing a numeric expression.

See Also

st_transform_proj, part of package lwgeom.

sf_project projects a matrix of coordinates, bypassing GDAL altogether

st_break_antimeridian

Examples

```
p1 = st_point(c(7,52))
p2 = st_point(c(-30,20))
sfc = st_sfc(p1, p2, crs = 4326)
sfc
st_transform(sfc, 3857)
st_transform(st_sf(a=2:1, geom=sfc), "EPSG:3857")
if (compareVersion(sf_extSoftVersion()["GDAL"], "3.0.0") >= 0) {
  st_transform(sfc, pipeline =
```

```
   "+proj=pipeline +step +proj=axisswap +order=2,1") # reverse axes
  st_transform(sfc, pipeline =
   "+proj=pipeline +step +proj=axisswap +order=2,1", reverse = TRUE) # also reverse axes
}
nc = st_read(system.file("shape/nc.shp", package="sf"))
st_area(nc[1,]) # area from long/lat
st_area(st_transform(nc[1,], 32119)) # NC state plane, m
st_area(st_transform(nc[1,], 2264)) # NC state plane, US foot
library(units)
set_units(st_area(st_transform(nc[1,], 2264)), m^2)
st_transform(structure(p1, proj4string = "EPSG:4326"), "EPSG:3857")
st_wrap_dateline(st_sfc(st_linestring(rbind(c(-179,0),c(179,0))), crs = 4326))
sf_proj_info("datum")
```

`st_viewport` *Create viewport from sf, sfc or sfg object*

Description

Create viewport from sf, sfc or sfg object

Usage

```
st_viewport(x, ..., bbox = st_bbox(x), asp)
```

Arguments

`x`	object of class sf, sfc or sfg object
`...`	parameters passed on to viewport
`bbox`	the bounding box used for aspect ratio
`asp`	numeric; target aspect ratio (y/x), see Details

Details

parameters `width`, `height`, `xscale` and `yscale` are set such that aspect ratio is honoured and plot size is maximized in the current viewport; others can be passed as `...`

If `asp` is missing, it is taken as 1, except when `isTRUE(st_is_longlat(x))`, in which case it is set to `1.0 /cos(y)`, with `y` the middle of the latitude bounding box.

Value

The output of the call to viewport

Examples

```
library(grid)
nc = st_read(system.file("shape/nc.shp", package="sf"))
grid.newpage()
pushViewport(viewport(width = 0.8, height = 0.8))
pushViewport(st_viewport(nc))
invisible(lapply(st_geometry(nc), function(x) grid.draw(st_as_grob(x, gp = gpar(fill = 'red')))))
```

---

st_write *Write simple features object to file or database*

Description

Write simple features object to file or database

Usage

```
st_write(obj, dsn, layer, ...)

## S3 method for class 'sfc'
st_write(obj, dsn, layer, ...)

## S3 method for class 'sf'
st_write(
  obj,
  dsn,
  layer = NULL,
  ...,
  driver = guess_driver_can_write(dsn),
  dataset_options = NULL,
  layer_options = NULL,
  quiet = FALSE,
  factorsAsCharacter = TRUE,
  append = NA,
  delete_dsn = FALSE,
  delete_layer = !is.na(append) && !append,
  fid_column_name = NULL,
  config_options = character(0)
)

## S3 method for class 'data.frame'
st_write(obj, dsn, layer = NULL, ...)

write_sf(..., quiet = TRUE, append = FALSE, delete_layer = !append)

st_delete(
  dsn,
```

```
  layer = character(0),
  driver = guess_driver_can_write(dsn),
  quiet = FALSE
)
```

Arguments

obj	object of class sf or sfc
dsn	data source name. Interpretation varies by driver: can be a filename, a folder, a database name, or a Database Connection (we officially test support for RPostgres::Postgres() connections).
layer	layer name. Varies by driver, may be a file name without extension; for database connection, it is the name of the table. If layer is missing, the basename of dsn is taken.
...	other arguments passed to dbWriteTable when dsn is a Database Connection
driver	character; name of driver to be used; if missing and dsn is not a Database Connection, a driver name is guessed from dsn; st_drivers() returns the drivers that are available with their properties; links to full driver documentation are found at https://gdal.org/en/latest/drivers/vector/index.html
dataset_options	character; driver dependent dataset creation options; multiple options supported.
layer_options	character; driver dependent layer creation options; multiple options supported.
quiet	logical; suppress info on name, driver, size and spatial reference
factorsAsCharacter	logical; convert factor levels to character strings (TRUE, default), otherwise into numbers when factorsAsCharacter is FALSE. For database connections, factorsAsCharacter is always TRUE.
append	logical; should we append to an existing layer, or replace it? if TRUE append, if FALSE replace. The default for st_write is NA which raises an error if the layer exists. The default for write_sf is FALSE, which overwrites any existing data. See also next two arguments for more control on overwrite behavior.
delete_dsn	logical; delete data source dsn before attempting to write?
delete_layer	logical; delete layer layer before attempting to write? The default for st_write is FALSE which raises an error if the layer exists. The default for write_sf is TRUE.
fid_column_name	character, name of column with feature IDs; if specified, this column is no longer written as feature attribute.
config_options	character, named vector with GDAL config options

Details

Columns (variables) of a class not supported are dropped with a warning.

When updating an existing layer, records are appended to it if the updating object has the right variable names and types. If names don't match an error is raised. If types don't match, behaviour is undefined: GDAL may raise warnings or errors or fail silently.

When deleting layers or data sources is not successful, no error is emitted. `delete_dsn` and `delete_layer` should be handled with care; the former may erase complete directories or databases.

`st_delete()` deletes layer(s) in a data source, or a data source if layers are omitted; it returns `TRUE` on success, `FALSE` on failure, invisibly.

Value

`obj`, invisibly

See Also

st_drivers, dbWriteTable

Examples

```
nc = st_read(system.file("shape/nc.shp", package="sf"))
st_write(nc, paste0(tempdir(), "/", "nc.shp"))
st_write(nc, paste0(tempdir(), "/", "nc.shp"), delete_layer = TRUE) # overwrites
if (require(sp, quietly = TRUE)) {
 data(meuse, package = "sp") # loads data.frame from sp
 meuse_sf = st_as_sf(meuse, coords = c("x", "y"), crs = 28992)
 # writes X and Y as columns:
 st_write(meuse_sf, paste0(tempdir(), "/", "meuse.csv"), layer_options = "GEOMETRY=AS_XY")
 st_write(meuse_sf, paste0(tempdir(), "/", "meuse.csv"), layer_options = "GEOMETRY=AS_WKT",
   delete_dsn=TRUE) # overwrites
## Not run:
 library(sp)
 example(meuse, ask = FALSE, echo = FALSE)
 try(st_write(st_as_sf(meuse), "PG:dbname=postgis", "meuse_sf",
     layer_options = c("OVERWRITE=yes", "LAUNDER=true")))
 demo(nc, ask = FALSE)
 try(st_write(nc, "PG:dbname=postgis", "sids", layer_options = "OVERWRITE=true"))

## End(Not run)
}
```

`st_z_range` *Return 'z' range of a simple feature or simple feature set*

Description

Return 'z' range of a simple feature or simple feature set

Usage

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

st_z_range(obj, ...)
```

```
## S3 method for class 'POINT'
st_z_range(obj, ...)

## S3 method for class 'MULTIPOINT'
st_z_range(obj, ...)

## S3 method for class 'LINESTRING'
st_z_range(obj, ...)

## S3 method for class 'POLYGON'
st_z_range(obj, ...)

## S3 method for class 'MULTILINESTRING'
st_z_range(obj, ...)

## S3 method for class 'MULTIPOLYGON'
st_z_range(obj, ...)

## S3 method for class 'GEOMETRYCOLLECTION'
st_z_range(obj, ...)

## S3 method for class 'MULTISURFACE'
st_z_range(obj, ...)

## S3 method for class 'MULTICURVE'
st_z_range(obj, ...)

## S3 method for class 'CURVEPOLYGON'
st_z_range(obj, ...)

## S3 method for class 'COMPOUNDCURVE'
st_z_range(obj, ...)

## S3 method for class 'POLYHEDRALSURFACE'
st_z_range(obj, ...)

## S3 method for class 'TIN'
st_z_range(obj, ...)

## S3 method for class 'TRIANGLE'
st_z_range(obj, ...)

## S3 method for class 'CIRCULARSTRING'
st_z_range(obj, ...)

## S3 method for class 'sfc'
st_z_range(obj, ...)
```

```
## S3 method for class 'sf'
st_z_range(obj, ...)

## S3 method for class 'numeric'
st_z_range(obj, ..., crs = NA_crs_)

NA_z_range_
```

Arguments

x	object of class z_range
obj	object to compute the z range from
...	ignored
crs	object of class crs, or argument to st_crs, specifying the CRS of this bounding box.

Details

NA_z_range_ represents the missing value for a z_range object

Value

a numeric vector of length two, with zmin and zmax values; if obj is of class sf or sfc the object returned has a class z_range

Examples

```
a = st_sf(a = 1:2, geom = st_sfc(st_point(0:2), st_point(1:3)), crs = 4326)
st_z_range(a)
st_z_range(c(zmin = 16.1, zmax = 16.6), crs = st_crs(4326))
```

---

st_zm *Drop or add Z and/or M dimensions from feature geometries*

Description

Drop Z and/or M dimensions from feature geometries, resetting classes appropriately

Usage

```
st_zm(x, ..., drop = TRUE, what = "ZM")
```

Arguments

x	object of class sfg, sfc or sf
...	ignored
drop	logical; drop, or (FALSE) add?
what	character which dimensions to drop or add

Details

Only combinations drop=TRUE, what = "ZM", and drop=FALSE, what="Z" are supported so far. In the latter case, x should have XY geometry, and zero values are added for the Z dimension.

Examples

```
st_zm(st_linestring(matrix(1:32,8)))
x = st_sfc(st_linestring(matrix(1:32,8)), st_linestring(matrix(1:8,2)))
st_zm(x)
a = st_sf(a = 1:2, geom=x)
st_zm(a)
```

---

summary.sfc *Summarize simple feature column*

Description

Summarize simple feature column

Usage

```
## S3 method for class 'sfc'
summary(object, ..., maxsum = 7L, maxp4s = 10L)
```

Arguments

object	object of class sfc
...	ignored
maxsum	maximum number of classes to summarize the simple feature column to
maxp4s	maximum number of characters to print from the PROJ string

---

tibble *Summarize simple feature type for tibble*

Description

Summarize simple feature type / item for tibble

Usage

```
type_sum.sfc(x, ...)

obj_sum.sfc(x)

pillar_shaft.sfc(x, ...)
```

Arguments

x	object of class sfc
...	ignored

Details

see type_sum

---

tidyverse *Tidyverse methods for sf objects*

Description

Tidyverse methods for sf objects. Geometries are sticky, use as.data.frame to let dplyr's own methods drop them. Use these methods after loading the tidyverse package with the generic (or after loading package tidyverse).

Usage

```
filter.sf(.data, ..., .dots)

arrange.sf(.data, ..., .dots)

group_by.sf(.data, ..., add = FALSE)

ungroup.sf(x, ...)

rowwise.sf(x, ...)

mutate.sf(.data, ..., .dots)

transmute.sf(.data, ..., .dots)

select.sf(.data, ...)

rename.sf(.data, ...)

rename_with.sf(.data, .fn, .cols, ...)

slice.sf(.data, ..., .dots)

summarise.sf(.data, ..., .dots, do_union = TRUE, is_coverage = FALSE)

count.sf(x, ..., wt = NULL, sort = FALSE, name = "n", .drop_geometry = FALSE)

distinct.sf(.data, ..., .keep_all = FALSE, exact = FALSE, par = 0)
```

```
gather.sf(
  data,
  key,
  value,
  ...,
  na.rm = FALSE,
  convert = FALSE,
  factor_key = FALSE
)

pivot_longer.sf(
  data,
  cols,
  names_to = "name",
  names_prefix = NULL,
  names_sep = NULL,
  names_pattern = NULL,
  names_ptypes = NULL,
  names_transform = NULL,
  names_repair = "check_unique",
  values_to = "value",
  values_drop_na = FALSE,
  values_ptypes = NULL,
  values_transform = NULL,
  ...
)

pivot_wider.sf(
  data,
  ...,
  id_cols = NULL,
  id_expand = FALSE,
  names_from = name,
  names_prefix = "",
  names_sep = "_",
  names_glue = NULL,
  names_sort = FALSE,
  names_vary = "fastest",
  names_expand = FALSE,
  names_repair = "check_unique",
  values_from = value,
  values_fill = NULL,
  values_fn = NULL,
  unused_fn = NULL
)

spread.sf(
```

```
  data,
  key,
  value,
  fill = NA,
  convert = FALSE,
  drop = TRUE,
  sep = NULL
)

sample_n.sf(tbl, size, replace = FALSE, weight = NULL, .env = parent.frame())

sample_frac.sf(
  tbl,
  size = 1,
  replace = FALSE,
  weight = NULL,
  .env = parent.frame()
)

group_split.sf(.tbl, ..., .keep = TRUE)

nest.sf(.data, ...)

separate.sf(
  data,
  col,
  into,
  sep = "[^[:alnum:]]+",
  remove = TRUE,
  convert = FALSE,
  extra = "warn",
  fill = "warn",
  ...
)

separate_rows.sf(data, ..., sep = "[^[:alnum:]]+", convert = FALSE)

unite.sf(data, col, ..., sep = "_", remove = TRUE)

unnest.sf(data, ..., .preserve = NULL)

drop_na.sf(x, ...)

inner_join.sf(x, y, by = NULL, copy = FALSE, suffix = c(".x", ".y"), ...)

left_join.sf(x, y, by = NULL, copy = FALSE, suffix = c(".x", ".y"), ...)

right_join.sf(x, y, by = NULL, copy = FALSE, suffix = c(".x", ".y"), ...)
```

```
full_join.sf(x, y, by = NULL, copy = FALSE, suffix = c(".x", ".y"), ...)

semi_join.sf(x, y, by = NULL, copy = FALSE, suffix = c(".x", ".y"), ...)

anti_join.sf(x, y, by = NULL, copy = FALSE, suffix = c(".x", ".y"), ...)
```

Arguments

.data	data object of class sf
...	other arguments
.dots	see corresponding function in package dplyr
add	see corresponding function in dplyr
x, y	A pair of data frames, data frame extensions (e.g. a tibble), or lazy data frames (e.g. from dbplyr or dtplyr). See *Methods*, below, for more details.
.fn, .cols	see original docs
do_union	logical; in case summary does not create a geometry column, should geometries be created by unioning using st_union, or simply by combining using st_combine? Using st_union resolves internal boundaries, but in case of unioning points, this will likely change the order of the points; see Details.
is_coverage	logical; if do_union is TRUE, use an optimized algorithm for features that form a polygonal coverage (have no overlaps)
wt	see original function docs
sort	see original function docs
name	see original function docs
.drop_geometry	logical; if TRUE, remove geometry column before computing counts
.keep_all	see corresponding function in dplyr
exact	logical; if TRUE use st_equals_exact for geometry comparisons
par	numeric; passed on to st_equals_exact
data	see original function docs
key	see original function docs
value	see original function docs
na.rm	see original function docs
convert	see separate_rows
factor_key	see original function docs
cols	see original function docs
names_to, names_pattern, names_ptypes, names_transform	see tidyr::pivot_longer()
names_prefix, names_sep, names_repair	see original function docs.
values_to, values_drop_na, values_ptypes, values_transform	See tidyr::pivot_longer()

id_cols, id_expand, names_from, names_sort, names_glue, names_vary, names_expand
: see tidyr::pivot_wider()

values_from, values_fill, values_fn, unused_fn
: see tidyr::pivot_wider()

fill
: see original function docs

drop
: see original function docs

sep
: see separate_rows

tbl
: see original function docs

size
: see original function docs

replace
: see original function docs

weight
: see original function docs

.env
: see original function docs

.tbl
: see original function docs

.keep
: see original function docs

col
: see separate

into
: see separate

remove
: see separate

extra
: see separate

.preserve
: see unnest

by
: A join specification created with join_by(), or a character vector of variables to join by.

  If NULL, the default, *_join() will perform a natural join, using all variables in common across x and y. A message lists the variables so that you can check they're correct; suppress the message by supplying by explicitly.

  To join on different variables between x and y, use a join_by() specification. For example, join_by(a == b) will match x$a to y$b.

  To join by multiple variables, use a join_by() specification with multiple expressions. For example, join_by(a == b, c == d) will match x$a to y$b and x$c to y$d. If the column names are the same between x and y, you can shorten this by listing only the variable names, like join_by(a, c).

  join_by() can also be used to perform inequality, rolling, and overlap joins. See the documentation at ?join_by for details on these types of joins.

  For simple equality joins, you can alternatively specify a character vector of variable names to join by. For example, by = c("a", "b") joins x$a to y$a and x$b to y$b. If variable names differ between x and y, use a named character vector like by = c("x_a" = "y_a", "x_b" = "y_b").

  To perform a cross-join, generating all combinations of x and y, see cross_join().

copy
: If x and y are not from the same data source, and copy is TRUE, then y will be copied into the same src as x. This allows you to join tables across srcs, but it is a potentially expensive operation so you must opt into it.

suffix
: If there are non-joined duplicate variables in x and y, these suffixes will be added to the output to disambiguate them. Should be a character vector of length 2.

Details

`select` keeps the geometry regardless whether it is selected or not; to deselect it, first pipe through `as.data.frame` to let dplyr's own `select` drop it.

In case one or more of the arguments (expressions) in the `summarise` call creates a geometry list-column, the first of these will be the (active) geometry of the returned object. If this is not the case, a geometry column is created, depending on the value of `do_union`.

In case `do_union` is `FALSE`, `summarise` will simply combine geometries using c.sfg. When polygons sharing a boundary are combined, this leads to geometries that are invalid; see for instance https://github.com/r-spatial/sf/issues/681.

The functions `count` and `tally` drop all geometries. For counting geometries use `summarise(.data, n = n(), .by = "geometry")`.

`distinct` gives distinct records for which all attributes and geometries are distinct; st_equals is used to find out which geometries are distinct.

`nest` assumes that a simple feature geometry list-column was among the columns that were nested.

Value

an object of class sf

Examples

```
if (require(dplyr, quietly = TRUE)) {
 nc = read_sf(system.file("shape/nc.shp", package="sf"))
 nc |> filter(AREA > .1) |> plot()
 # plot 10 smallest counties in grey:
 st_geometry(nc) |> plot()
 nc |> select(AREA) |> arrange(AREA) |> slice(1:10) |> plot(add = TRUE, col = 'grey')
 title("the ten counties with smallest area")
 nc2 <- nc |> mutate(area10 = AREA/10)
 nc |> slice(1:2)
}
# plot 10 smallest counties in grey:
if (require(dplyr, quietly = TRUE)) {
 st_geometry(nc) |> plot()
 nc |> select(AREA) |> arrange(AREA) |> slice(1:10) |> plot(add = TRUE, col = 'grey')
 title("the ten counties with smallest area")
}
if (require(dplyr, quietly = TRUE)) {
 nc$area_cl = cut(nc$AREA, c(0, .1, .12, .15, .25))
 nc |> group_by(area_cl) |> class()
}
if (require(dplyr, quietly = TRUE)) {
 nc2 <- nc |> mutate(area10 = AREA/10)
}
if (require(dplyr, quietly = TRUE)) {
 nc |> transmute(AREA = AREA/10) |> class()
}
if (require(dplyr, quietly = TRUE)) {
 nc |> select(SID74, SID79) |> names()
```

```
 nc |> select(SID74, SID79) |> class()
}
if (require(dplyr, quietly = TRUE)) {
 nc2 <- nc |> rename(area = AREA)
}
if (require(dplyr, quietly = TRUE)) {
 nc |> slice(1:2)
}
if (require(dplyr, quietly = TRUE)) {
 nc$area_cl = cut(nc$AREA, c(0, .1, .12, .15, .25))
 nc.g <- nc |> group_by(area_cl)
 nc.g |> summarise(mean(AREA))
 nc.g |> summarise(mean(AREA)) |> plot(col = grey(3:6 / 7))
 nc |> as.data.frame() |> summarise(mean(AREA))
 # counting geometries (after duplicating each row):
 nc.dupl <- nc[rep(seq_along(nc), each = 2), ]
 nc.dupl |> summarise(n = n(), .by = "geometry")
}
if (require(dplyr, quietly = TRUE)) {
  nc$area_cl <- cut(nc$AREA, c(0, .1, .12, .15, .25))
  nc |> count(area_cl, .drop_geometry = TRUE)
}
if (require(dplyr, quietly = TRUE)) {
 nc[c(1:100, 1:10), ] |> distinct() |> nrow()
}
if (require(tidyr, quietly = TRUE) && require(dplyr, quietly = TRUE) && "geometry" %in% names(nc)) {
 nc |> select(SID74, SID79) |> gather("VAR", "SID", -geometry) |> summary()
}
if (require(tidyr, quietly = TRUE) && require(dplyr, quietly = TRUE) && "geometry" %in% names(nc)) {
 nc$row = 1:100 # needed for spread to work
 nc |> select(SID74, SID79, geometry, row) |>
 gather("VAR", "SID", -geometry, -row) |>
 spread(VAR, SID) |> head()
}
if (require(tidyr, quietly = TRUE) && require(dplyr, quietly = TRUE)) {
 storms.sf = st_as_sf(storms, coords = c("long", "lat"), crs = 4326)
 x <- storms.sf |> group_by(name, year) |> nest()
 trs = lapply(x$data, function(tr) st_cast(st_combine(tr), "LINESTRING")[[1]]) |>
    st_sfc(crs = 4326)
 trs.sf = st_sf(x[,1:2], trs)
 plot(trs.sf["year"], axes = TRUE)
}
```

`transform.sf` *transform method for sf objects*

Description

Can be used to create or modify attribute variables; for transforming geometries see st_transform, and all other functions starting with `st_`.

Usage

```
## S3 method for class 'sf'
transform(`_data`, ...)
```

Arguments

_data	object of class sf
...	Further arguments of the form new_variable = expression

Examples

```
a = data.frame(x1 = 1:3, x2 = 5:7)
st_geometry(a) = st_sfc(st_point(c(0,0)), st_point(c(1,1)), st_point(c(2,2)))
transform(a, x1_sq = x1^2)
transform(a, x1_x2 = x1*x2)
```

---

valid *Check validity or make an invalid geometry valid*

Description

Checks whether a geometry is valid, or makes an invalid geometry valid

Usage

```
st_is_valid(x, ...)

## S3 method for class 'sfc'
st_is_valid(x, ..., NA_on_exception = TRUE, reason = FALSE)

## S3 method for class 'sf'
st_is_valid(x, ...)

## S3 method for class 'sfg'
st_is_valid(x, ...)

st_make_valid(x, ...)

## S3 method for class 'sfg'
st_make_valid(x, ...)

## S3 method for class 'sfc'
st_make_valid(
  x,
  ...,
  oriented = FALSE,
  s2_options = s2::s2_options(snap = s2::s2_snap_precision(1e+07), ...),
```

```
  geos_method = "valid_structure",
  geos_keep_collapsed = TRUE
)
```

Arguments

x	object of class sfg, sfc or sf
...	passed on to s2_options
NA_on_exception	logical; if TRUE, for polygons that would otherwise raise a GEOS error (exception, e.g. for a POLYGON having more than zero but less than 4 points, or a LINESTRING having one point) return an NA rather than raising an error, and suppress warning messages (e.g. about self-intersection); if FALSE, regular GEOS errors and warnings will be emitted.
reason	logical; if TRUE, return a character with, for each geometry, the reason for invalidity, NA on exception, or "Valid Geometry" otherwise.
oriented	logical; only relevant if st_is_longlat(x) is TRUE; see s2
s2_options	only relevant if st_is_longlat(x) is TRUE; options for s2_rebuild, see s2_options and Details.
geos_method	character; either "valid_linework" (Original method, combines all rings into a set of noded lines and then extracts valid polygons from that linework) or "valid_structure" (Structured method, first makes all rings valid then merges shells and subtracts holes from shells to generate valid result. Assumes that holes and shells are correctly categorized.) (requires GEOS >= 3.10.1)
geos_keep_collapsed	logical; When this parameter is not set to FALSE, the "valid_structure" method will keep any component that has collapsed into a lower dimensionality. For example, a ring collapsing to a line, or a line collapsing to a point (requires GEOS >= 3.10.1)

Details

For projected geometries, st_make_valid uses the lwgeom_makevalid method also used by the PostGIS command ST_makevalid if the GEOS version linked to is smaller than 3.8.0, and otherwise the version shipped in GEOS; for geometries having ellipsoidal coordinates s2::s2_rebuild is being used.

if s2_options is not specified and x has a non-zero precision set, then this precision value will be used as the value in s2_snap_precision, passed on to s2_options, rather than the 1e7 default.

Value

st_is_valid returns a logical vector indicating for each geometries of x whether it is valid. st_make_valid returns an object with a topologically valid geometry.

Object of the same class as x

Examples

```
p1 = st_as_sfc("POLYGON((0 0, 0 10, 10 0, 10 10, 0 0))")
st_is_valid(p1)
st_is_valid(st_sfc(st_point(0:1), p1[[1]]), reason = TRUE)
library(sf)
x = st_sfc(st_polygon(list(rbind(c(0,0),c(0.5,0),c(0.5,0.5),c(0.5,0),c(1,0),c(1,1),c(0,1),c(0,0)))))
suppressWarnings(st_is_valid(x))
y = st_make_valid(x)
st_is_valid(y)
y |> st_cast()
```

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