rgeos

spatial geometry predicates and topology operations in R

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Package Overview

What is GEOS?

- Implements all the OpenGIS Consortium's Simple Feature Access for SQL specification
- C++ port of the Java Topology Suite
- Available under the LGPL
- Geometry engine behind open source project like PostGIS, SpatiaLite, QGIS, ...

Package Overview

What is `rgeos`?

- Brings the functionality of GEOS to R
- Developed in collaboration with Roger Bivand and Edzer Pebesma
- Official GSoC project in Summer 2010
- Implements the majority of the v1.6.2 C API (GEOS 3.2.2 and above)
- Written to integrate with R spatial packages (`sp`, `maptools`, etc.)
- Available on CRAN

OGC Simple Feature Access for SQL

Common standard for the representation of Geospatial data

- Specifies common 2d geometric data types:
  - Point / MultiPoint
  - LineString / MultiLineString
  - Polygon / MultiPolygon
  - LinearRing
  - GeometryCollection
- Also specifies attributes, methods, and assertions for these geometries
- Common exchange formats: Well-known text, Well-known binary
- Standard - http://www.opengeospatial.org/standards/sfs

sp and SFS

sp classes are very similar but differ in several critical ways from SFS data types

- No native support for GeometryCollections or LinearRings (SpatialRings and SpatialCollections added in rgeos)
- Translation ambiguities
  - Should a SpatialPolygons object be a GeometryCollection of Polygons or a single MultiPolygon?
- Differences in Polygon implementation

Topology Operations

Boolean

- gDifference
- gIntersection
- gSymdifference
- gUnion

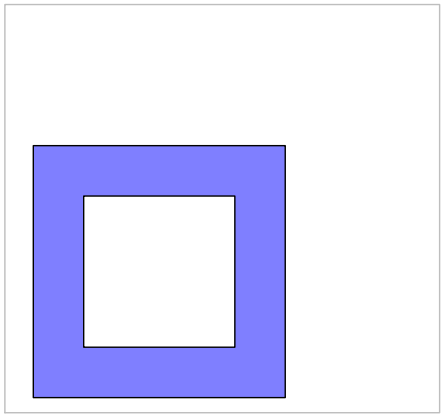
Constructive

- gBoundary
- gBuffer
- gCentroid
- gConvexHull
- gEnvelope
- gLineMerge
- gPointOnSurface
- gPolygonize
- gSimplify
- gUnionCascaded / gUnionUnary

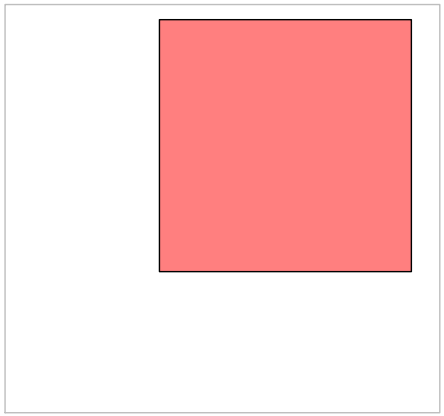
Metric

- gArea
- gDistance
- gLength

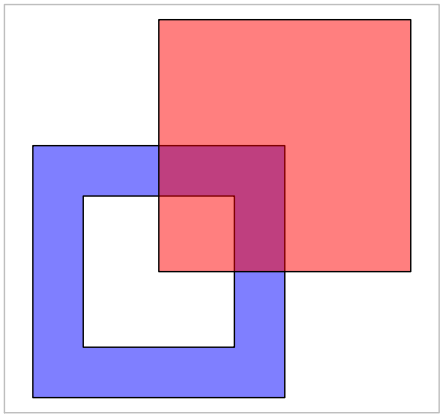
Topology - Boolean



X

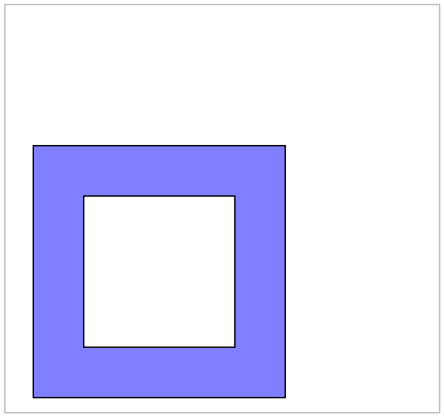


Y

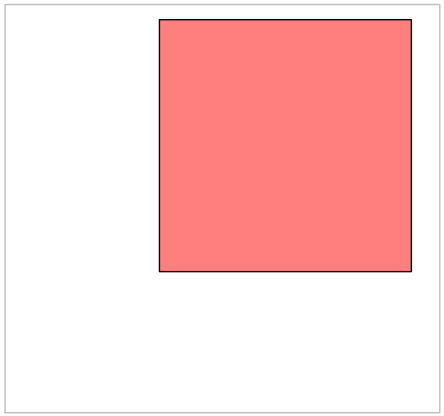


X and Y

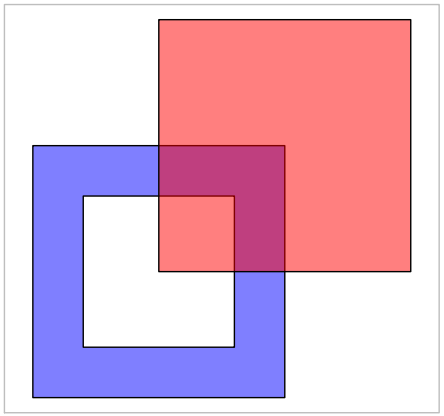
Topology - Boolean



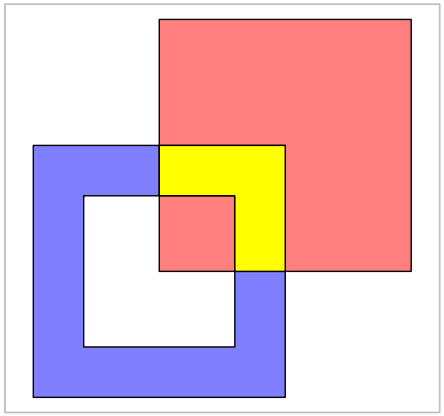
X



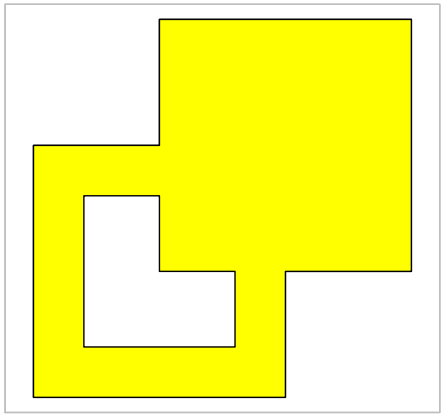
Y



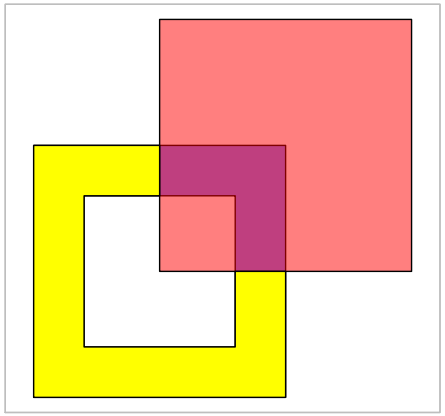
X and Y



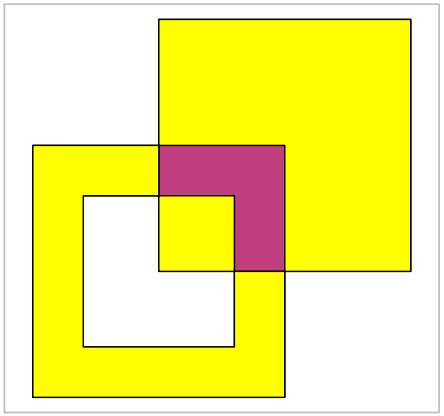
gIntersection



gUnion



gDifference



gSymdifference

rgeos and gpclib

The original impetus for rgeos was the need to replace Roger Peng's gpclib package which implemented these boolean operations for polygons.

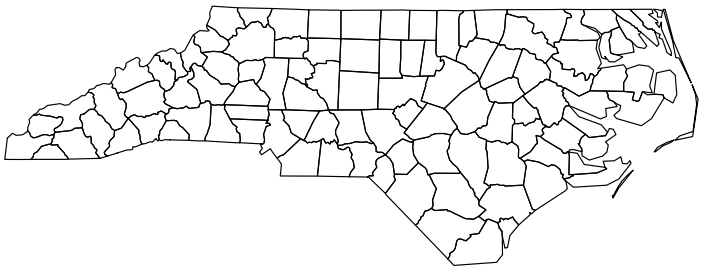
- gpclib is a wrapper around Alan Murta's General Polygon Clipper library
- The GPC library has a restrictive license (free only for non-commercial use)
- The GPC library is limited to polygon clipping (boolean operations)
- gpclib uses gpc.poly S4 classes

rgeos has functionality to transparently replace gpclib for the purposes of backwards compatibility

Topology - Constructive

Example

```
library(maptools)
nc = readShapePoly(
        system.file("shapes/sids.shp", package="maptools")[1],
        proj4string=CRS("+proj=longlat +datum=NAD27")
     )
pts = coordinates(nc)
ID = cut(pts[,1], quantile(pts[,1]), include.lowest=TRUE)
nc_regions = gUnionCascaded(nc, ID)
```



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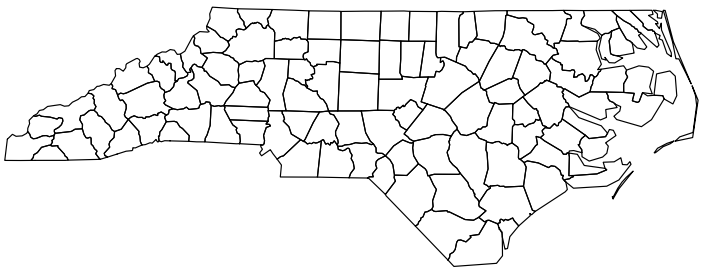
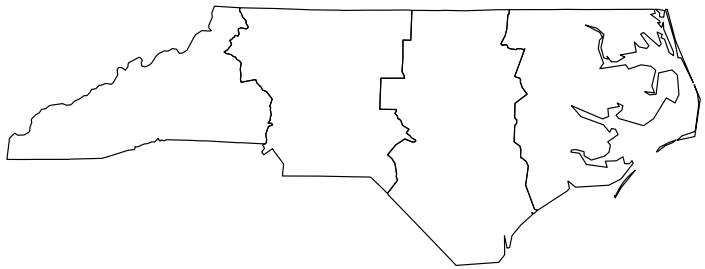




Spatial Predicates

Unary

- gIsEmpty
- gIsRing
- gIsSimple
- gIsValid

Binary

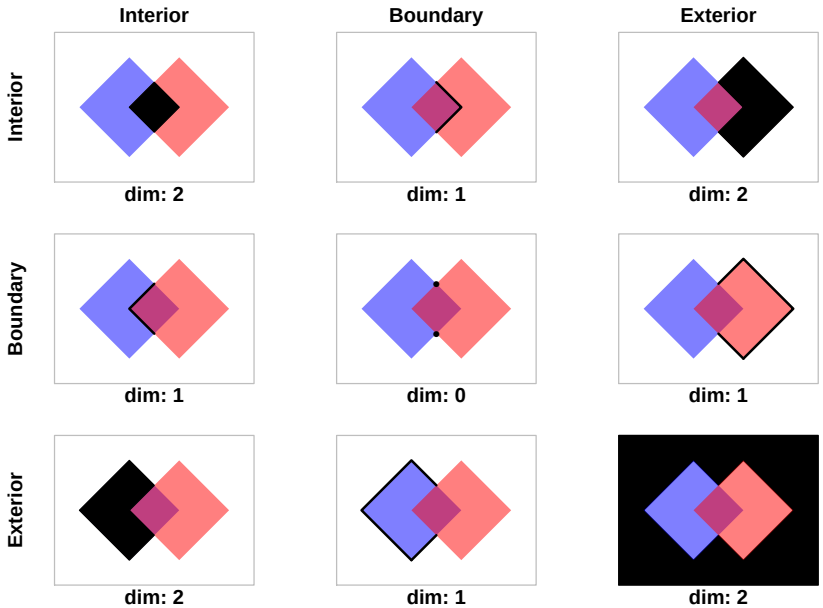
- gContains
- gContainsProperly
- gCovers
- gCoveredBy
- gCrosses
- gDisjoint
- gEquals
- gEqualsExact
- gOverlaps
- gRelate
- gTouches
- gWithin
- gWithinDistance

Package Documentation and JTS Technical Specifications cover the specifics of these functions.

gRelate and DE-9IM

Binary predicates are based on the Dimensionally Extended 9-Intersection Model

- Reports the dimensionality of the intersection of the interiors, boundaries, and exteriors
- Possible values: 0, 1, 2, F, T, *



$\Rightarrow$ "212101212"

gRelate and DE-9IM

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- Reports the dimensionality of the intersection of the interiors, boundaries, and exteriors
- Possible values: 0, 1, 2, F, T, *

DE-9IM Pattern	Function	f(x,y)
FF*FF****	gDisjoint	false
FT*******	gTouches	false
T*T***T**	gCrosses	true
TF*F*****	gWithin	false
T*T***T**	gOverlaps	true

For a more details - http://bit.ly/Kxm6iz or http://bit.ly/L1uifo

Spatial Predicates and Prepared Geometries

Common usage pattern with spatial predicates will involve a single geometry being compared to a series of test geometries.

- Initial Geometry is reused for each subsequent predicate
- Many of the underlying calculations / data structures can be cached
- In some cases evaluation steps can be skipped
- Potentially huge performance gains for minimal overhead (on by default when possible)
- This is an area of recent development activity for GEOS hence:
  - CAPI v1.6.2 (GEOS v3.2.2) supports: Contains, ContainsProperly, Covers, Intersects
  - CAPI v1.7.0 (GEOS v3.3+) added support for: CoveredBy, Crosses, Disjoint, Overlaps, Touches, Within

Prepared Geometry Performance

Example

```
library(maptools)

data(wrld_simpl)
US = wrld_simpl[wrld_simpl@data$NAME == "United States",]

gt = GridTopology(c(-180,-90),c(0.5,0.5),c(720,360))
grid = SpatialGrid(gt)
sp = as(grid, "SpatialPoints")
proj4string(sp) = proj4string(US)

system.time(gIntersects(US,sp,byid=TRUE,prepared=TRUE))
system.time(gIntersects(US,sp,byid=TRUE,prepared=FALSE))
```

Prepared Geometry Performance

Example

```
library(maptools)

data(wrld_simpl)
US = wrld_simpl[wrld_simpl@data$NAME == "United States",]

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sp = as(grid, "SpatialPoints")
proj4string(sp) = proj4string(US)

system.time(gIntersects(US,sp,byid=TRUE,prepared=TRUE))
system.time(gIntersects(US,sp,byid=TRUE,prepared=FALSE))
```

prepared=TRUE

user	system	elapsed
0.220	0.016	0.285

prepared=FALSE

user	system	elapsed
244.851	0.004	244.895

Future Work

- Complete update to GEOS C API 1.7.0 while preserving backwards compatibility
- Refine usability of STRtree spatial indexes
- Add support for WKB
- Clean up documentation / Package vignette

Questions, Comments, Bugs?

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github	:	http://github.com/rundel/rgeos