R, GRASS, and Spatial Analysis

cengel - June/06

- Geospatial Data Attributes
- R Language Packages
  - overview
  - example
- GRASS-R combo
  - issues, considerations, …
Geospatial data

- **data attributes:**
  - geographic location coordinates ("georeferenced")
  - 2 or 3 dimensional
  - vector and raster file formats
- **data processing:**
  - import, conversion
  - projection, re-projection, alignment of multiple datasets, resampling
- **data analysis:**
  - visualization
  - EDA
  - spatial statistics
  - (GIS operations, eg. create new layers)

Spatial Statistics

- **what you might want to do..**
  - **spatial point processing**
    - distribution of location of events (random, regular, clustered)
  - **spatial autocorrelation**
    - correlation of location of events
  - **smoothing, interpolation**
    - create surfaces from few known data
  - **geostatistics**
    - predict spatial distributed features
R geospatial packages

- **sp**
  - foundation classes, interface to coordinate systems, utility plotting methods, sampling methods
    - http://finzi.psych.upenn.edu/R/library/sp/html/00Index.html

### sp

#### spatial classes provided by package sp

<table>
<thead>
<tr>
<th>data type</th>
<th>class</th>
<th>attributes</th>
<th>extends</th>
</tr>
</thead>
<tbody>
<tr>
<td>points</td>
<td>SpatialPoints</td>
<td>none</td>
<td>Spatial*</td>
</tr>
<tr>
<td>points</td>
<td>SpatialPointsDataFrame</td>
<td>AttributeList</td>
<td>SpatialPoints*</td>
</tr>
<tr>
<td>pixels</td>
<td>SpatialPixels</td>
<td>none</td>
<td>SpatialPoints*</td>
</tr>
<tr>
<td>pixels</td>
<td>SpatialPixelsDataFrame</td>
<td>AttributeList</td>
<td>SpatialPixels*</td>
</tr>
<tr>
<td>full grid</td>
<td>SpatialGrid</td>
<td>none</td>
<td>SpatialPixels*</td>
</tr>
<tr>
<td>full grid</td>
<td>SpatialGridDataFrame</td>
<td>AttributeList</td>
<td>SpatialGrid*</td>
</tr>
<tr>
<td>line</td>
<td>Line</td>
<td>none</td>
<td>Line list</td>
</tr>
<tr>
<td>lines</td>
<td>Lines</td>
<td>none</td>
<td>Line list</td>
</tr>
<tr>
<td>lines</td>
<td>SpatialLines</td>
<td>none</td>
<td>Spatial*, Lines list</td>
</tr>
<tr>
<td>lines</td>
<td>SpatialLinesDataFrame</td>
<td>data.frame</td>
<td>SpatialLines*</td>
</tr>
<tr>
<td>polygon</td>
<td>Polygon</td>
<td>none</td>
<td>Line*</td>
</tr>
<tr>
<td>polygons</td>
<td>Polygons</td>
<td>none</td>
<td>Polygon list</td>
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<tr>
<td>polygons</td>
<td>SpatialPolygons</td>
<td>none</td>
<td>Spatial*, Polygons list</td>
</tr>
<tr>
<td>polygons</td>
<td>SpatialPolygonsDataFrame</td>
<td>data.frame</td>
<td>SpatialPolygons*</td>
</tr>
</tbody>
</table>

* by direct extension; ** by setIs() relationship;
methods provided by package sp

<table>
<thead>
<tr>
<th>method</th>
<th>what it does</th>
</tr>
</thead>
<tbody>
<tr>
<td>[</td>
<td>select spatial items (points, lines, polygons, or rows/cols from a grid) and/or attributes variables</td>
</tr>
<tr>
<td>$, $&lt;-, [[-, [[&lt;-</td>
<td>retrieve, set or add attribute table columns</td>
</tr>
<tr>
<td>ssample</td>
<td>sample points from a set of polygons, on a set of lines or from a gridded area, using the simple sampling methods given in Ripley (1981)</td>
</tr>
<tr>
<td>splot</td>
<td>lattice (Trellis) plots of spatial variables (figure 3; see text)</td>
</tr>
<tr>
<td>bbox</td>
<td>give the bounding box</td>
</tr>
<tr>
<td>proj4string</td>
<td>get or set the projection (coordinate reference system)</td>
</tr>
<tr>
<td>coordinates</td>
<td>set or retrieve coordinates</td>
</tr>
<tr>
<td>polygons</td>
<td>set or retrieve polygons</td>
</tr>
<tr>
<td>gridded</td>
<td>verify whether an object is a grid, or convert to a gridded format</td>
</tr>
<tr>
<td>dimensions</td>
<td>get the number of spatial dimensions</td>
</tr>
<tr>
<td>coerce</td>
<td>convert from one class to another</td>
</tr>
<tr>
<td>transform</td>
<td>(re-)project spatial coordinates (uses sproj)</td>
</tr>
<tr>
<td>overlay</td>
<td>combine two different spatial objects (see text)</td>
</tr>
<tr>
<td>recenter</td>
<td>shift or re-center geographical coordinates for a Pacific view</td>
</tr>
</tbody>
</table>

more R geospatial packages (selection)

- **maptools**
  - reading and handling of shape files

- **maps**
  - drawing of basic geographical maps

- **spgpc**
  - polygon clipping

- **spGDAL (Geospatial Data Abstraction Library)**
**R spatial statistics packages**

(Selection)

- **spatial**
  - core methods spatial point pattern analysis
    - part of the VR bundle (shipped with base R)
- **spatstat**
  - 2D point patterns multitype/marked points and spatial covariates, functions for exploratory data analysis, model-fitting, simulation, model diagnostics, and formal inference.
    - http://www.spatstat.org
- **splancs**
  - space-time, emphasis on points-within-polygons
- **spdep**
  - spatial regression, autocorrelation
    - http://finzi.psych.upenn.edu/R/library/spdep/html/00Index.html

**more R spatial statistics packages**

(Selection)

- **gstat**
  - univariate and multivariate geostatistics
    - (large datasets)
- **geoR, geoRglm**
  - model based geostatistics
- **fields**
  - curve and function fitting with an emphasis on splines, spatial data and spatial statistics (large datasets)
- **spatialCovariance**
more R packages

- **RArcInfo**
  - reads ArcInfo version 7 and e00 files

- **shapefiles**
  - reads and writes ESRI shapefiles

- **RColorBrewer**
  - color palettes optimized for thematic maps

References

- **Rgeo by spatial analysis Lab, U Illinois**
  - [http://sal.uiuc.edu/csiss/Rgeo/](http://sal.uiuc.edu/csiss/Rgeo/)

- **R-spatial on Sourceforge**
  - [http://r-spatial.sourceforge.net/](http://r-spatial.sourceforge.net/)

- **Map packages on CRAN**
  - [http://cran.r-project.org/src/contrib/Views/Spatial.html](http://cran.r-project.org/src/contrib/Views/Spatial.html)
spatial analysis with GRASS

- GRASS 5 replaced with GRASS 6
  - fundamental changes in handling vectors and attributes -> database

- directory structure

  DATABASE  
  /[homdir]/grass_data

  LOCATIONS
  regionA/  regionB/  regionC

  MAPSETS
  PERMANENT/ (r)  
  user1/ (rw)  
  user2/  ...

spatial analysis with GRASS

- available methods
  d.* display commands
  db.* database commands
  g.* general commands
  g3.* general3D commands
  i.* imagery commands
  p.* paint commands
  pg.* postGRASS commands
  ps.* postscript commands
  r.* raster commands
  r3.* raster3D commands
  v.* vector commands
  m.* miscellaneous commands
  s.* site manipulation commands

- extensibility (write your own code)
spatial analysis with GRASS

- **typical things being done with GRASS**
  - Erosion/hydrologic/terrain modeling,
  - visualization,
  - image processing, raster analysis,
  - landscape structure analysis (r.le)

- **often combined with R**

R/GRASS interface

- **library (GRASS)**
  - primarily data interface between R and GRASS5

- **library (spgrass6)**
  - recently released interface between R and GRASS 6
  - based on sp package
  - to provide vector and raster data interfaces
References

- **Manuals**
  - http://grass.itc.it/grass61/manuals/html61_user/full_index.html
  - http://grass.itc.it/gdp/manuals.php (searchable)
- **GRASS WIKI**
  - http://grass.gdf-hannover.de/wiki/Documents
- **g.manual -- command line**