Some examples of use of the **GeoXp** package (version 1.5.0)

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1 Description of the basic functionalities

1.1 General principles

An interactive function[1] of the **GeoXp** package can be called by using one of these following codes:

- `function(sp.obj, name.var,...,options)`, if there is only one variable of interest,
- `function(sp.obj, names.var,...,options)`, if there are several variables of interest,
- `function(sp.obj, name.var, nb.obj...,options)`, if there is one variable of interest and the use of a spatial weight matrix.

The first argument `sp.obj` is a Spatial Class object as defined by R. Bivand in **sp** package. It contains both spatial coordinates and characteristics of spatial units.

Presently, **GeoXp** draws a map, considering spatial units like points: a spatial unit is defined geographically by two scalars x and y. Indeed, for drawing a map, the spatial coordinates of spatial units have been extracted from `sp.obj` by using the function `coordinates`, which can be applied on to any Spatial Class object (`SpatialPointsDataFrame`, `SpatialPolygonsDataFrame`, etc).

It also prints a statistical graphic. The variable(s) of interest are given by `name.var` or `names.var`, a (vector of) character (or numeric) which indicates the column(s) of the `sp.obj@data` to be used in the analysis. The `sp.obj@data` is by construction, a

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[1]The non interactive functions included in **GeoXp** correspond to internal or wrap functions

data.frame.

In the function call, the ... correspond to specificities of each function (more details in 3). For example, it could indicate the number of bars for a histogram, if the y-axis should represent or not the count or the percent for a barplot, etc....

Finally, options are common to most of the functions (with some small specificities by function) and described in the following section. Let us start with a simple example.

1.2 An elementary use

This first example has been taken from the example of the histomap function. We consider a data set included in **GeoXp**, containing price indices of real estate from largest cities in France in 2008.

```
> data(immob)
> class(immob)
```

```
[1] "data.frame"
```

```
> names(immob)
```

```
 [1] "Nom"              "Code.INSEE"         "Code.region"
 [4] "longitude"        "latitude"           "prix.vente"
 [7] "variation.vente"  "prix.location"      "variation.location"
[10] "rentabilite"
```

As we can see above, this data set is a data.frame containing the spatial coordinates of the cities in the variables longitude and latitude. It also contains several variables corresponding to the city names, the selling and renting prices, etc...

The first operation consists in creating a Spatial Object. First, we have to create a SpatialPoints object by specifying a $2 \times d$ matrix with longitude and latitude:

```
> immob.sp = SpatialPoints(cbind(immob$longitude,immob$latitude))
> class(immob.sp)
```

```
[1] "SpatialPoints"
attr(,"package")
[1] "sp"
```

The second operation consists in creating a SpatialPointsDataFrame by coupling a SpatialPoints object with a data.frame:

```
> immob.spdf = SpatialPointsDataFrame(immob.sp, immob)
> class(immob.spdf )
```

```
[1] "SpatialPointsDataFrame"
attr(,"package")
[1] "sp"
```

Finally, we can call the function histomap by giving as first argument, the Spatial Object and as second argument, we give a character (it can also be the number of the column, here the value 6) which corresponds to the name of the variable of interest. It results in the opening of a Tk window and two devices, a device with number 2 which corresponds to the map and a device with number 3 corresponding to the statistical graph, in this case, the histogram:

```
> histomap(immob.spdf,"prix.vente")
```

As we can see in the Fig. 1, the Tk window contains several buttons that the user can click on: the user may select a point (`Point` button) or a polygon (`Polygon` button) on the map and may also select a bar on the histogram (`Cell` button). In this example, the user may also print bubbles by clicking on `Bubbles` after choosing a numerical variable among the variables included in the Spatial object.

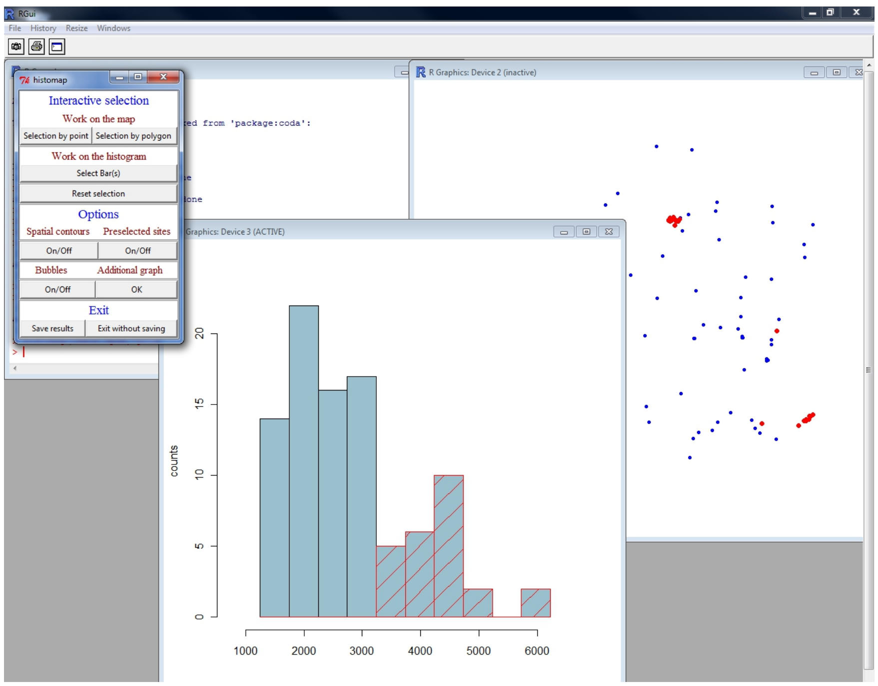


Figure 1: The tk window and the two devices

1.3 Saving results

By default, interactive functions don't return results anymore since version 1.5.0. Presently, the user has to click on the `Save results` button to create a global object called `last.select` which is in most cases, a vector of integers containing the number of the spatial units selected at the final step. However, for spatial econometrics functions using a spatial weight matrix, `last.select` is a $2 \times d$ matrix, because the selection is done on couples of sites (see 3).

1.4 Functions cannot be opened simultaneously

At this moment, the user can only open one interactive function at a time. He has to close the Tk window by clicking on `Save results` or `Exit without saving` before opening a new function.

2 Description of the Options

2.1 The options

```
function(sp.obj,...,
names.attr=names(sp.obj), criteria=NULL, carte=NULL,
identify=FALSE, cex.lab=0.8, pch=16, col="lightblue3",
xlab="angle", ylab="absolute magnitude", axes=FALSE,
lablong="", lablat="")
```

Most of these options are common to all functions. It can differ depending on the function, but the principles remain the same.

- `names.attr`: a vector of character of size the number of variables included in `sp.obj@data`. The option is used for changing the variable names included in the `sp.obj@data`
- criteria: a vector of boolean of size the number of spatial units; it allows to represent preselected sites with a green cross, by clicking on `preselected sites` on the Tk window
- `carte`: in the case where `sp.obj` is a `SpatialPolygonDataFrame`, the user will have the opportunity to draw the polygons of Spatial unit by using the `Draw Spatial contours` button in the Tk window. However, if the `sp.obj` is a `SpatialPointsDataFrame`, the user may specify by using the `carte` option, a matrix with 2 columns for drawing spatial polygonal contours: x and y coordinates of the vertices of the polygon. The functions `polylist2list()` and `spdf2list()` convert some spatial objects (`Polylist` and `SpatialPolygonDataFrame`) into matrices as decribed above to draw a background map.
- `identify`: if TRUE, the names of selected sites will be printed on the map. The names of spatial units correpond to `row.names` of the attribute table `row.names(sp.obj@data)`.
- `cex.lab`: a numeric value, it gives the character size of labels
- `pch`: 16 by default, it gives the symbol for selected points
- `col`: "lightblue3" by default, it gives the color of the bars of a histogram, the points of a scatter plot, etc... In the case where the variable of interest is a factor, the user may give a vector of colors corresponding to the colors of each level to be printed on the map.
- `xlab`: a character, title for the graphic x-axis
- `ylab`: a character, title for the graphic y-axis
- `axes`: a boolean with TRUE for drawing axes on the map

- `lablong`: a character, name of the x-axis that will be printed on the map
- `lablat`: a character, name of the y-axis that will be printed on the map

2.2 An example with options

We consider the data set `immob` again. We would like to draw as background on the map the spatial contours of the 21 regions in the metropolitan France[2] included in a `shapefile`. For this, we first use the function `readShapePoly`, included in the **maptools** package, to import the file. Then, we use the function `spdf2list` to convert the `SpatialPolygonsDataFrame` into a matrix of numeric with 2 columns (x and y):

```
> midiP <- readShapePoly(system.file("shapes/region.shp", package="GeoXp")[1])
> cont_midiP<-spdf2list(midiP[-c(22,23),])$poly
```

We also create a vector of boolean which cuts approximately the France in two areas, North and South:

```
> criteria <- (immob$latitude>mean(immob$latitude))
```

In the following code, the option `nbcol=15` and `type = "percent"` are specific to the function `histomap`. The first one indicates the number of bars to draw and the second the fact that the y-axis of the graphic should represent the percentage of individuals. Notice that the variable of interest corresponds here to the 7th variable of the `sp.obj`, i.e. the variation of selling price observed between 2007 and 2008.

```
> histomap(immob.spdf, 7, nbcol=15, type = "percent",
+ names.attr=names(immob), criteria=criteria, carte=cont_midiP,
+ identify=TRUE, cex.lab=0.5, pch=12, col="pink",
+ xlab="variation price", ylab="percent", axes=TRUE, lablong="x",
+ lablat="y")
```

On Fig. 2, we have represented the two devices after selecting the bars with high values of the variable of interest, clicking on the `Bubbles` button (and choosing the variable `prix.vente`, average selling price) and clicking on the `Preselected sites` button.

The result on the map and on the graphic is that the selected spatial units are represented in red. Besides on the map, the sites have different sizes depending on the values taken by `prix.vente` and there is a green croice for the cities of the North.

If the user clicks on the `Save results` button, he obtains the following message and can use the `last.select` object thus created:

```
[1] "Results have been saved in last.select object"
> last.select
 [1] 12 18 24 31 32 37 39 42 49 67 73 74 79 81 84
```

3 The main functions of GeoXp

We succinctly describe here the statistical graphic, the specific options and the dependencies with other packages.

[2]We have excluded here the regions 22 and 23 which corresponds to the Corse and Andorre

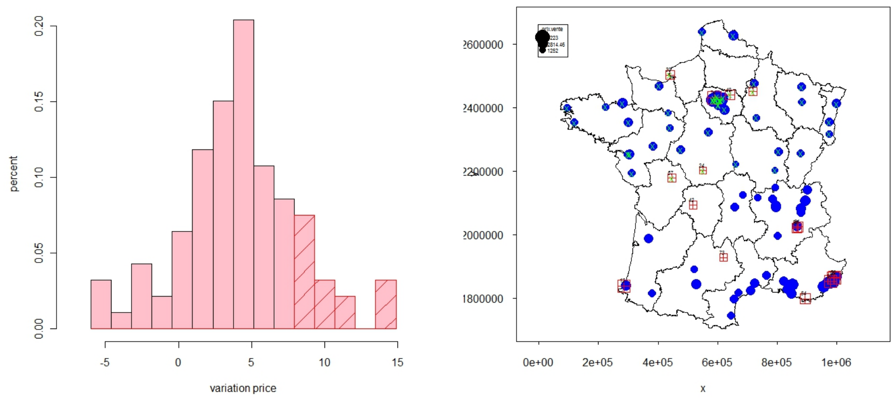


Figure 2: The use of options in the `histomap` function

3.1 Functions with one variable of interest

- `angleplotmap`: absolute difference between the value of `name.var` at two sites as a function of the angle between vector $\overrightarrow{s_i s_j}$ and the x-axis. A specific option is `quantiles`, for drawing a conditionnal quantile curve.
- `barmap`: bar plot (vertical bar) of the given factor variable `name.var`. Specific options are `type` to specify the type of the value on the y-axis (count or percent) and `names.arg` to specify the names of levels of `name.var`.
- `boxplotmap`: boxplot of the given variable *name.var*.
- `densitymap`: kernel density estimates of the variable `name.var` with the `bkde` function of the **KernSmooth** package. A specific option is `kernel` for the choice of kernel.
- `driftmap`: the device is divided into 2 rows and 2 columns which contains :
  - cell 1:the selected sites divided into m rows and q columns (m and q are selected with the tk window),
  - cell 2: a scatter plot with `coordinates(sp.obj)[,2]` on the x-axis and the mean and median of `name.var` calculated for the m rows on the y-axis,
  - cell 3: a scatter plot with the mean and median of `name.var` calculated for the q columns in x-axis and `coordinates(sp.obj)[,1]` in y-axis,
  - cell 4: a legend indicating the direction of the North. Specific options are `name.var`, `interpol=TRUE`, `nuage=TRUE`, `lty=1:2`, `cex=0.7` (see the help of the function for more details).

- `ginimap`: Lorentz curve from `name.var` and calculates the Gini Index associated to `name.var`.
- `histomap`: histogram of a given variable `name.var`. Specific options are `nbcol` for the number of bars and `type` for the values to print on the y-axis (`count`, `percent` or `density`)
- `variocloudmap`: semi-variocloud (directional or omnidirectional) and a map. Specific options are `bin` which indicates the values on the x-axis where the variocloud will be evaluated and `quantiles` for drawing a conditionnal quantile curve.

3.2 Functions with several variables of interest

- `clustermap`: classification of the sites from the variables included in `names.var` and computes a bar plot of the resulting clusters. Specific options are `clustnum` which gives the number of cluster, `method`, which gives the method to use, `type`, `center`, `scale` which gives indication on the method (see `help(clustermap)`) and `names.arg`.
- `dbledensitymap`: two kernel density estimates from 2 variables. Specific option is `kernel` for the choice of kernel.
- `dblehistomap`: two histograms of the given variables `names.var[1]` and `names.var[2]`. Specific options are `nbcol` and `type`.
- `histobarmap`: bar plot (vertical bar) of the given variable `names.var[1]` and histogram of the given variable `names.var[2]`. Specific options are `type` and `names.arg`.
- `pcamap`: plots summarizing a generalized Principal Component Analysis (PCA), made with `genpca` (wrap function). It draws the scatterplot of the individuals projected on a chosen principal component plane (with their percentage of inertia), together with the scatterplot of the variables projected into the same plane with the quality of representation in order to interpret the principal component axes. Specific options are `direct`, `weight`, `metric`, `center`, `reduce` and `qualproj` (see `help(pcamap)`).
- `plot3dmap`: 3d-plot of three given variables *names.var*. Specific options are `box` for drawing a cube and `zlab`. It depends on the package **rgl**.
- `polyboxplotmap`: parallel Boxplots of a numerical variable by levels of a factor. Specific options are `varwidth` and `names.arg`
- `scattermap`: scatterplot of the given variables indicated in `names.var`.

An example of multivariate function
We consider the function debledensitymap. It takes as argument a Spatial object and a vector of character with the name (or the column numbers) of the variables:

```
> dbledensitymap(immob.spdf,c("prix.vente","prix.location"),
+ xlab=c("selling price","rending price"),identify=TRUE, cex.lab=0.5,
+ carte=cont_midiP)
```

In this example, we have selected on the first density distribution estimation, by clicking directly on the graphic, cities with a selling price lower than 2000. The corresponding sub-density of this selection has been drawn on the second graphic.

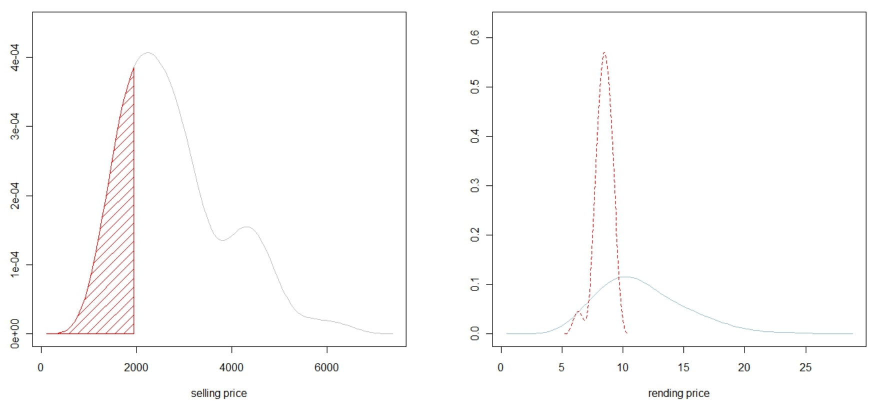


Figure 3: example of the dbledensitymap function

3.3 Function with variable(s) of interest and a spatial weight matrix

- misolationmap: scatterplot with the pairwise Mahalanobis distances calculated using variables names.var between the observations and their neighbors on the y-axis and the "degree of isolation" of the observations on the x-axis. It depends on **mvoutlier** and **robustbase** packages. Specific options are propneighb and chisqqu

- moranplotmap: moran plot, on the x-axis, is represented x and on the y-axis $W \times x$, where W is the spatial weight matrix. It also calcultes Moran's I statistic (see nonnormoran) and give a p-value associated to the autocorrelation test (gaussian version and permutation version). Specific options are flower, locmoran and names.arg.

- mvariocloudmap: scatterplot of pairwise Mahalanobis distances and spatial distances with a map. It is a multivariate version of the variocloud. The number of couples of sites plotted can be reduced by considering couples above a quantile regression curve. It depends on **mvoutlier** and **robustbase** packages. A specific option is `quantiles`.

- `neighbourmap`: scatterplot of the values of the variable at neighbouring sites for a neighbourhood structure given by a binary weight matrix W.

The two functions `barnbmap` and `histnbmap` analyse a spatial neigborhood structure and have not a `name.var` argument.

3.4 Other dependencies

The quantile spline regression drawn on the scatterplot with option `quantiles` comes from the function `qsreg` included in the **fields** package. The **splancs** package is called for the use of the `inout` function.

4 A example of Spatial econometric function

We present here the example proposed by the `neighbourmap` function using the same data set `immob`.

4.1 Construction of a spatial weight matrix

The package **spdep** contains several functions for building spatial weight matrices. These functions create an `nb` object which corresponds to the class used in the **GeoXp** functions. For example, the `tri2nb` function builds a spatial weight matrix based on the Delaunay triangulation:

```
> W.nb<-tri2nb(cbind(immob$longitude,immob$latitude))
> class(W.nb)
```

```
[1] "nb"
```

With **GeoXp**, the function `makeneighborsw` builds a spatial weight matrix by using both methods of the nearest neighbors and the threshold distance. However, the result is included in a `matrix` object and the user will have to convert this object into an `nb` object by using the function `mat2listw`, as follows:

```
> W2.matrix<-makeneighborsw(cbind(immob$longitude,immob$latitude),method="both",m=5,d=175000)
> W2.nb<-mat2listw(W2.matrix)$neighbours
> class(W2.nb)
```

```
[1] "nb"
```

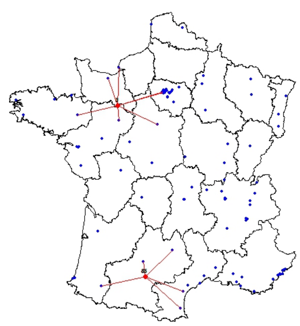
Note that the functions `histnbmap` and `barnbmap` included in **GeoXp** allow an interactive exploratory analysis of the neighborhood structure given by an `nb` object.

4.2 Example of use of a spatial econometric function

In the following example, we consider the variable “average selling price of a house by square meter” and use the `neighbourmap`. We indicate as third element, the spatial weight matrix of class `nb`.

```
> neighbourmap(immob.spdf,"prix.vente", W.nb, identify=TRUE, cex.lab=0.5,
+ carte=cont_midiP)
```

In this example, we have selected two cities on the map. The value of the city observed in the North corresponds on the scatterplot to the axis of the first column of points represented in red. The points represented in red in this column corresponds to the neighbours of the city selected on the map. The fact that the points are located above the line $y = x$ means that the city selected is a local "outlier" in the sense that the value taken is lower than its neighbours. For the second city selected in the South, it is the reverse.



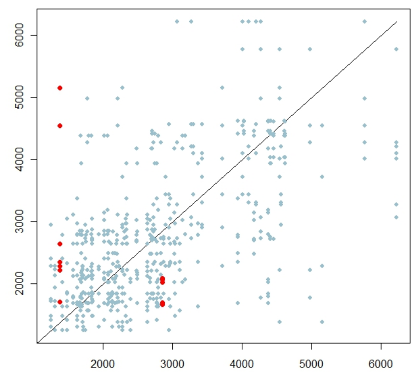


Figure 4: The use of options in histomap function

In this case, when the user selects the `Save result` button, it creates in the `last.select` object a matrix containing the couples of selected sites:

```
[1] "Results have been saved in last.select object"
> last.select
      [,1] [,2]
 [1,]    3   17
 [2,]    3   38
 [3,]    3   39
 [4,]    3   40
 [5,]    3   63
 [6,]    3   70
 [7,]    3   90
 [8,]   85   53
 [9,]   85   58
[10,]   85   65
[11,]   85   66
[12,]   85   73
```