Package ‘lctools’

July 29, 2014

Version 0.1-3

Date 2014-07-30

Type Package

Title Local Correlation, Spatial Inequalities and other tools

Author Stamatis Kalogirou

Maintainer Stamatis Kalogirou <skalo@hua.gr>

Depends R (>= 3.1.1), reshape (>= 0.8.5), weights (>= 0.80)

Description Local Correlation Coefficients (Local Pearson and Geographically Weighted Pearson), Spatial Inequality Measures (Gini, Spatial Gini, LQ, Focal LQ), Spatial Autocorrelation (Moran's I) and other Spatial Analysis tools (Geographically Weighted Statistics, Inferential Statistics)

License GPL (>= 2)

URL http://gisc.gr

NeedsCompilation no

Repository CRAN

Date/Publication 2014-07-29 07:38:22

R topics documented:

`lctools-package` *Local correlation coefficients, spatial inequality statistics and other tools*

Description

The main purpose of lctools is to assist spatial analysis researchers and educators to use simple, yet powerful, transparent and user friendly tools for calculating key spatial statistics. Lctools was originally created to help testing the existence of local multi-collinearity among the explanatory variables of local regression models. The main function (lcorrel) allows the computation of Local Pearson and Geographically Weighted Pearson Correlation Coefficients and their significance. However, it can also be used for examining the existence of local association between pairs of variables. As spatial analysis techniques develop, this package has other spatial statistical tools: spatial decomposition of the Gini, spatial/Focal LQ, Moran's I and tools that help to compute variables for Spatial Interaction Models. This package also contains functions for statistical inference for each statistic calculated.

Details

Package:	lctools
Type:	Package
Version:	0.1-3
Date:	2014-07-30
License:	GPL (>= 2)

Note

Acknowledgement: I am grateful to the University of Luxembourg and would like to personally thank Ass. Professor Geoffrey Caruso and Professor Christian Schulz for their support during my research visit at the Institute of Geography and Spatial Planning (Sept. 2013 - Feb. 2014) where this package was originally developed.

Author(s)

Stamatis Kalogirou

Maintainer: Stamatis Kalogirou <skalo@hua.gr

References

Hope, A.C.A. (1968) A Simplified Monte Carlo Significance Test Procedure, Journal of the Royal Statistical Society. Series B (Methodological), 30 (3), pp. 582 - 598.

Kalogirou, S., 2003, The Statistical Analysis And Modelling Of Internal Migration Flows Within England And Wales, PhD Thesis, School of Geography, Politics and Sociology, University of Newcastle upon Tyne, UK.

Kalogirou, S. (2012) Testing local versions of correlation coefficients, Review of Regional Research - Jahrbuch fur Regionalwissenschaft, 32, 1, pp. 45 - 61, doi: 10.1007/s10037-011-0061-y.

Kalogirou, S. (2013) Testing geographically weighted multicollinearity diagnostics, GISRUK 2013, Department of Geography and Planning, School of Environmental Sciences, University of Liverpool, Liverpool, UK, 3-5 April 2013. http://gisc.gr/docs/sk_papers/2_7_Kalogirou_2013.pdf

Rey, S.J., Smith J.S., 2013, A spatial decomposition of the Gini coefficient, Letters in Spatial and Resource Sciences, 6 (2), pp. 55-70.

`acc` *Spatial Interaction Models: Destination Accessibility*

Description

Destination accessibility or centrality or competition is a variable that when added to a destination choice model forms the competing destinations choice model. A simple formula for this variable is:

$$A_j = \Sigma(W_m/D_{jm})|m <> j$$

where Aj is the potential accessibility of destination j to all other potential destinations m, Wm is a weight generally measured by population, and Djm is the distance between j and m.

Usage

```
acc(X, Y, Pop, Power=1)
```

Arguments

`X`	a numeric vector of x coordinates
`Y`	a numeric vector of y coordinates
`Pop`	a numeric vector of the weights, usually a population variable
`Power`	a power of the distance; default is 1

Value

`AccMeasure`	a single column numeric matrix of accessibility scores

Note

X,Y should be Cartesian coordinates for the distances to be measured in meters. In the sample dataset GreeceLAs the projection used is the EPSG:2100 (GGRS87 / Greek Grid)

Author(s)

Stamatis Kalogirou <skalo@hua.gr>

References

Kalogirou, S., 2003, The Statistical Analysis And Modelling Of Internal Migration Flows Within England And Wales, PhD Thesis, School of Geography, Politics and Sociology, University of Newcastle upon Tyne, UK. URL: https://theses.ncl.ac.uk/dspace/handle/10443/204

Examples

```
data(GreeceLAs)
aMeasure<-acc(GreeceLAs$X[1:100], GreeceLAs$Y[1:100],GreeceLAs$totalp[1:100],1)
```

FLQ *Focal Location Quotient*

Description

This is the implementation of the Focal Location Quotients proposed by Cromley and Hanink (2012). The function calculates the standard LQ and the Focal LQ based on a kernel of nearest neighbours. Two weighted schemes are currently supported: binary and bi-square weights for a fixed number of nearest neighbours set by the user.

Usage

```
FLQ(Coords, Bandwidth, e, E, Denominator, WType = "Bi-square")
```

Arguments

`Coords`	a numeric matrix or vector or dataframe of two columns giving the X,Y coordinates of the observations (data points or geometric / population weighted centroids)
`Bandwidth`	a positive value that defines the number of nearest neighbours for the calculation of the weights
`e`	a numeric vector of a variable e_i as in the nominator of the Equation 1 (Cromley and Hanink, 2012) referring to the employment in a given sector for each location
`E`	a numeric vector of a variable E_i as in the nominator of the Equation 1 (Cromley and Hanink, 2012) referring to the total employment in a given sector for each location

`Denominator` a ratio as in the denominator (e/E) of the Equation 1 (Cromley and Hanink, 2012), where e and E are total employment in the given sector and overall employment in the reference economy, respectively.

`WType` string giving the weighting scheme used to compute the weights matrix. Options are: "Binary", "Bi-square". Default is "Bi-square".

Binary: weight = 1 for distances less than or equal to the distance of the furthest neighbour (H), 0 otherwise;

Bi-square: weight = (1-(ndist/H)^2)^2 for distances less than or equal to H, 0 otherwise

Value

FLQ returns a list of 2 vectors

`LQ` A numeric vector with the Location Quotient values

`FLQ` A numeric vector with the Focal Location Quotient values

Author(s)

Stamatis Kalogirou <skalo@hua.gr>

References

Cromley, R. G. and Hanink, D. M. (2012), Focal Location Quotients: Specification and Application, Geographical Analysis, 44 (4), pp. 398-410. doi: 10.1111/j.1538-4632.2012.00852.x

Examples

```
data(VotesGR)

Coords1<-cbind(VotesGR$X, VotesGR$Y)
Bandwidth1<-4
Denom<-0.2966

res<-FLQ(Coords1,Bandwidth1,VotesGR$NDJune12,VotesGR$AllJune12,Denom)
boxplot(res)
```

`GreeceLAs` *Local Authorities in Greece in 2001*

Description

Centroid coordinates and census population in 2001 for the 1033 Local Authorities in Greece

Usage

```
data(GreeceLAs)
```

Format

A data frame with 1033 observations on the following 4 variables.

`Area` A 4-digit area code of each local authority linking to the 2001 Census Data

`X` a numeric vector of x coordinates

`Y` a numeric vector of y coordinates

`totalp` a numeric vector of the total population of the local authority in 2001 (Census)

Details

The X,Y coordinates refer to the geometric centroids of the Local Authorities in Greece in 2001 (Kapodistrias).

Source

The shapefile of the corresponding polygons is available from the Public Open Data of the Greek Government at http://geodata.gov.gr/geodata. The population data is available from the Hellenic Statistical Authority (EL.STAT.) at http://www.statistics.gr.

References

The map of local authorities can be seen in this paper:

Kalogirou, S., 2010, Spatial inequalities in income and post-graduate educational attainment in Greece, Journal of Maps, 6, 1, pp. 393-400. doi: 10.4113/jom.2010.1095.

Examples

```
data(GreeceLAs)
summary(GreeceLAs$totalp)
plot(GreeceLAs$X,GreeceLAs$Y)
```

`GreeceNew` *Municipalities in Greece in 2011*

Description

Centroid coordinates and employment variables from the 2001 Census aggregated to the new 325 Municipalities in Greece (Kallikrates)

Usage

```
data(GreeceNew)
```

Format

A data frame with 325 observations on the following 5 variables.

`ID` a numeric vector of area IDs

`X` a numeric vector of x coordinates

`Y` a numeric vector of y coordinates

`PrimSector` a numeric vector of the proportion of economically active working in the primary financial sector (mainly agriculture; fishery; and forestry)

`UnemplRate` a numeric vector of total unemployment rate

Details

The X,Y coordinates refer to the geometric centroids of the new 325 Municipalities in Greece (Kallikrates) in 2011. The new municipalities were aggregated from the old 1033 Local Authorities (Kapodistrias) in 2007.

Source

The shapefile of the corresponding polygons is available from the Public Open Data of the Greek Government at http://geodata.gov.gr/geodata. The population data is available from the Hellenic Statistical Authority (EL.STAT.) at http://www.statistics.gr but were aggregated to the new municipalities by the author.

References

Kalogirou, S. (2013) Testing geographically weighted multicollinearity diagnostics, GISRUK 2013, Department of Geography and Planning, School of Environmental Sciences, University of Liverpool, Liverpool, UK, 3-5 April 2013. http://gisc.gr/docs/sk_papers/2_7_Kalogirou_2013.pdf

Examples

```
data(GreeceNew)
summary(GreeceNew$UnemplRate)
hist(GreeceNew$PrimSector)
plot(GreeceNew$X,GreeceNew$Y)
```

`gw_variable` *Spatial Interaction Models: gw / regional variable*

Description

Regional variables are meant to capture the possible pull effects on internal out-migration caused by conditions elsewhere in the country (Fotheringham et al., 2002; 2004). For example (see code below), the regional variable of the total population is calculated as an index that compares the total population in a zone with the total population of the surrounding zones weighted by a second power of distance. It is used to capture a pull effect produced when an origin is surrounded by very populous zones that draw migrants from the origin (Kalogirou, 2013). Nearby locations are weighted more heavily in the calculation than more distant ones, adopting the idea of the Tobler's first law of Geography. Thus, this variable could be referred to as gw (geographically weighted) variable.

Usage

```
gw_variable(Coords, InputVariable)
```

Arguments

`Coords`	a numeric matrix or vector or dataframe of two columns giving the X,Y coordinates of the observations (data points or geometric / population weighted centroids)
`InputVariable`	a numeric vector of a variable

Value

`Regional`	a single column numeric matrix of the regional variable

Note

This code has been tested with Cartesian coordinates for the distances to be measured in meters. In the sample dataset GreeceLAs the projection used is the EPSG:2100 (GGRS87 / Greek Grid)

Author(s)

Stamatis Kalogirou <skalo@hua.gr>

References

Fotheringham, A.S., Barmby, T., Brunsdon, C., Champion, T., Charlton, M., Kalogirou, S., Tremayne, A., Rees, P., Eyre, H., Macgill, J., Stillwell, J., Bramley, G., and Hollis, J., 2002, Development of a Migration Model: Analytical and Practical Enhancements, Office of the Deputy Prime Minister. URL: https://www.academia.edu/5274441/Development_of_a_Migration_Model_Analytical_and_Practical_Enhancements

Fotheringham, A.S., Rees, P., Champion, T., Kalogirou, S., and Tremayne, A.R., 2004, The Development of a Migration Model for England and Wales: Overview and Modelling Out-migration, Environment and Planning A, 36, pp. 1633 - 1672. doi:10.1068/a36136

Kalogirou, S., 2003, The Statistical Analysis And Modelling Of Internal Migration Flows Within England And Wales, PhD Thesis, School of Geography, Politics and Sociology, University of Newcastle upon Tyne, UK. URL: https://theses.ncl.ac.uk/dspace/handle/10443/204

Examples

```
data(GreeceLAs)
GrCoords<-cbind(GreeceLAs$X[1:100], GreeceLAs$Y[1:100])
Regional_Population <-gw_variable(GrCoords,GreeceLAs$totalp[1:100])
```

`lcorrel` *Local Pearson and GW Pearson Correlation*

Description

This function computes Local Pearson and Geographically Weighted Pearson Correlation Coefficients and tests for their statistical significance. Because the local significant tests are not independent, under the multiple hypotheses testing theory, a Bonferroni correction of the local coefficients takes place. The function results in tables with results for all possible pairs of the input variables.

Usage

```
lcorrel(DFrame, bw, Coords)
```

Arguments

`DFrame`	A numeric Data Frame of at least two variables
`bw`	A positive value between 0 and 1 to define the proportion of the total observations for the local sample for which each time the local coefficients are calculated for. This can be also the result of bandwidth selection algorithms of local regression techniques such as the Geographically Weighted Regression (GWR)
`Coords`	a numeric matrix or vector or data frame of two columns giving the X,Y coordinates of the observations (data points or geometric centroids)

Details

The degrees of freedom for the local t-student test is Round(bw * Number of Observations) - 2.

Value

lcorrel returns a list of 7 Data Frames

`LPCC`	A numeric data frame with the Local Pearson Correlation Coefficients (LPCCs) for each possible pair of the input variables in DFrame
`LPCC_t`	A numeric data frame with the t-student test statistics for all LPCCs
`LPCC_sig`	A numeric data frame with level of significance (p-value) for all LPCCs
`LPCC_sig_BF`	A numeric data frame with level of significance (p-value) for all LPCCs adjusted using the conservative Bonferroni correction to account for false positives under the multiple hypothesis testing theory
`GWPCC`	A numeric data frame with the Geographically Weighted Pearson Correlation Coefficients (GWPCCs) for each possible pair of the input variables in DFrame

GWPCC_sig A numeric data frame with level of significance (p-value) for all GWPCCs

GWPCC_sig_BF A numeric data frame with level of significance (p-value) for all GWPCCs adjusted using the conservative Bonferroni correction to account for false positives under the multiple hypothesis testing theory

Author(s)

Stamatis Kalogirou <skalo@hua.gr>

References

Kalogirou, S., 2012, Testing local versions of correlation coefficients, Review of Regional Research - Jahrbuch fur Regionalwissenschaft, 32, 1, pp. 45 - 61, doi: 10.1007/s10037-011-0061-y.

Kalogirou, S., 2013, Testing geographically weighted multicollinearity diagnostics, GISRUK 2013, Department of Geography and Planning, School of Environmental Sciences, University of Liverpool, Liverpool, UK, 3-5 April 2013.http://gisc.gr/docs/sk_papers/2_7_Kalogirou_2013.pdf

Examples

```
data(VotesGR)
local.cor<-lcorrel(VotesGR[5:6],0.1,cbind(VotesGR$X, VotesGR$Y))
plot(local.cor$LPCC[,2],local.cor$GWPCC[,2])
```

---

mc.lcorrel *Monte Carlo simulation for the significance of the local correlation coeficients*

Description

In order to assess if the spatial variation of the local correlation coefficients is statistically significant this function computes original and simulated statistics. LPCCs and GWPCCs can be calculated for a fixed bandwidth for the original locations of the observations as well as for a user-defined number of geographical reallocations of the observations. The latter is a simple Monte Carlo simulation proposed by Hope (1968) and adopted by Fotheringham et al. (2002) who assess if local parameter estimates in a Geographically Weighted Regression model exhibit spatial non-stationarity. First, the variances of LPCCs and GWPCCs, respectively, are computed for observed and simulated local correlation coefficients. Then, a pseudo p-value is calculated as p=(1+C)/(1+M) where C is the number of cases in which the variance of the simulated LPCCs and GWPCCs is equal to or higher than the variance of the observed LPCCs and GWPCCs, respectively of each test, and M is the number of permutations. If p<=0.05 it can be argued that the spatial variation of the local correlation coefficients is statistically significant. For this approach, a minimum of 19 permutations is required.

Usage

```
mc.lcorrel(Nsim=99,bwSIM,CorVars,Coord.X,Coord.Y)
```

Arguments

`Nsim`	a positive integer that defines the number of the simulation's iterations
`bwSIM`	A positive value between 0 and 1 to define the proportion of the total observations for the local sample for which each time the local correlation coefficients will be calculated for.
`CorVars`	A data frame of two variables for which observed and simulated local correlation coefficients (LPCCs and GWPCCs) will be calculated for.
`Coord.X`	a numeric vector giving the X coordinates of the observations (data points or geometric centroids)
`Coord.Y`	a numeric vector giving the Y coordinates of the observations (data points or geometric centroids)

Details

For 0.05 level of significance in social sciences, a minimum number of 19 simulations (Nsim>=19) is required. We recommend at least 99 and at best 999 iterations

Value

Returns a list of summary statistics for the simulated values of LPCCs and GWPCCs, the observed LPCCs and GWPCCs and the pseudo p-value of significance for the spatial variation of the LPCCs and GWPCCs, respectivelly

`SIM`	a dataframe with simulated values: SIM.ID is the simulation ID, SIM.gwGini is the simulated Gini of neighbours, SIM.nsGini is the simulated Gini of non-neighbours, SIM.SG is the simulated share of the overall Gini that is associated with non-neighbour pairs of locations, SIM.Extr = 1 if the simulated SG is greater than or equal to the observed SG
`LC.Obs`	list of 7 Data Frames as in lcorrel
`pseudo.p.lpcc`	pseudo p-value for the significance of the spatial variation of the LPCCs: if this is lower than or equal to 0.05 it can be argued that the the spatial variation of the LPCCs is statistically significant.
`pseudo.p.gwpcc`	pseudo p-value for the significance of the spatial variation of the GWPCCs: if this is lower than or equal to 0.05 it can be argued that the the spatial variation of the GWPCCs is statistically significant.

Author(s)

Stamatis Kalogirou <skalo@hua.gr>

References

Hope, A.C.A. (1968) A Simplified Monte Carlo Significance Test Procedure, Journal of the Royal Statistical Society. Series B (Methodological), 30 (3), pp. 582 - 598.

Fotheringham, A.S, Brunsdon, C., Charlton, M. (2002) Geographically Weighted Regression: the analysis of spatially varying relationships, Chichester: John Wiley and Sons.

Examples

```
X<-rep(11:14, 4)
Y<-rev(rep(1:4, each=4))
var1<-c(1,1,1,1,1,1,2,2,2,2,3,3,3,4,4,5)
var2<-rev(var1)
Nsim= 19
bwSIM<-0.5

SIM20<-mc.lcorrel(Nsim,bwSIM, cbind(var1,var2),X,Y)

SIM20$pseudo.p.lpcc
SIM20$pseudo.p.gwpcc
```

---

mc.spGini *Monte Carlo simulation for the significance of the Spatial Gini coefficient*

Description

This function provides one approach for inference on the spatial Gini inequality measure. This is a small Monte Carlo simulation according to which: a) the data are spatially reallocated in a random way; b) the share of overall inequality that is associated with non-neighbour pairs of locations - SG (Eq. 5 in Rey & Smith, 2013) - is calculated for the original and simulated spatial data sets; c) a pseudo p-value is calculated as p=(1+C)/(1+M) where C is the number of the permutation data sets that generated SG values that were as extreme as the observed SG value for the original data (Eq. 6 in Rey & Smith, 2013). If p<=0.05 it can be argued that the component of the Gini for non-neighbour inequality is statistically significant. For this approach, a minimum of 19 simulations is required.

Usage

```
mc.spGini(Nsim=99,Bandwidth,x,Coord.X,Coord.Y,WType='Binary')
```

Arguments

Nsim	a positive integer that defines the number of the simulation's iterations
Bandwidth	a positive integer that defines the number of nearest neighbours for the calculation of the weights
x	a numeric vector of a variable
Coord.X	a numeric vector giving the X coordinates of the observations (data points or geometric centroids)
Coord.Y	a numeric vector giving the Y coordinates of the observations (data points or geometric centroids)

WType — string giving the weighting scheme used to compute the weights matrix. Options are: "Binary", "Bi-square", "RSBi-square". Default is "Binary".

Binary: weight = 1 for distances less than or equal to the distance of the furthest neighbour (H), 0 otherwise;

Bi-square: weight = (1-(ndist/H)^2)^2 for distances less than or equal to H, 0 otherwise;

RSBi-square: weight = Bi-square weights / sum (Bi-square weights) for each row in the weights matrix

Details

For 0.05 level of significance in social sciences, a minimum number of 19 simulations (Nsim>=19) is required. We recommend at least 99 and at best 999 iterations

Value

Returns a list of the simulated values, the observed Gini and its spatial decomposition, the pseudo p-value of significance

SIM — a dataframe with simulated values: SIM.ID is the simulation ID, SIM.gwGini is the simulated Gini of neighbours, SIM.nsGini is the simulated Gini of non-neighbours, SIM.SG is the simulated share of the overall Gini that is associated with non-neighbour pairs of locations, SIM.Extr = 1 if the simulated SG is greater than or equal to the observed SG

spGini.Observed — Observed Gini (Gini) and its spatial components (gwGini, nsGini)

pseudo.p — pseudo p-value: if this is lower than or equal to 0.05 it can be argued that the component of the Gini for non-neighbour inequality is statistically significant.

Note

Acknowledgement: I would like to thank LI Zai-jun, PhD student at Nanjing Normal University, China for encouraging me to develop this function and for testing this package.

Author(s)

Stamatis Kalogirou <skalo@hua.gr>

References

Rey, S.J., Smith J.S., 2013, A spatial decomposition of the Gini coefficient, Letters in Spatial and Resource Sciences, 6 (2), pp. 55-70.

Examples

```
data(GreeceNew)
Nsim=19
Bd1<-4
x1<-GreeceNew$UnemplRate[1:45]
WType1<-'Binary'
```

```
SIM20<-mc.spGini(Nsim,Bd1,x1,GreeceNew$X[1:45], GreeceNew$Y[1:45],WType1)
SIM20

hist(SIM20$SIM$SIM.nsGini,col = "lightblue", main = "Observed and simulated nsGini",
xlab = "Simulated nsGini", ylab = "Frequency",xlim = c(min(SIM20$SIM$SIM.nsGini),
SIM20$spGini.Observed[[3]]))
abline(v=SIM20$spGini.Observed[[3]], col = 'red')
```

---

moransI *Moran's I classic statistic for assessing spatial autocorrelation*

Description

Moran's I is one of the oldest statistics used to examine spatial autocorrelation. This global statistic was first proposed by Moran (1948, 1950). Later, Cliff and Ord (1973, 1981) present a comprehensive work on spatial autocorrelation and suggested a formula to calculate the I which is now used in most textbooks and software:

$$I = (n/W) * (\Sigma\Sigma w_i j * z_i * z_j / \Sigma z_i^2)$$

where n is number of observations, W is the sum of the weights w_ij for all pairs in the system, z_i=x_i - mean(x) where x is the value of the variable at location i and mean(x) the mean value of the variable in question (Eq. 5.2 Kalogirou, 2003).The implementation here allows only nearest neighbour weighting schemes. Resampling and randomization null hypotheses have been tested following the discussion of Goodchild (1986, pp. 24-26).

Usage

```
moransI(Coords, Bandwidth, x, WType = "Binary")
```

Arguments

`Coords`	a numeric matrix or vector or data frame of two columns giving the X,Y coordinates of the observations (data points or geometric / population weighted centroids)
`Bandwidth`	a positive integer that defines the number of nearest neighbours for the calculation of the weights
`x`	a numeric vector of a variable
`WType`	string giving the weighting scheme used to compute the weights matrix. Options are: "Binary" and "Bi-square". Default is "Binary". Binary: weight = 1 for distances less than or equal to the distance of the furthest neighbour (H), 0 otherwise; Bi-square: weight = (1-(ndist/H)^2)^2 for distances less than or equal to H, 0 otherwise.

Details

The Moran's I statistic ranges from -1 to 1. Values in the interval (-1, 0) indicate negative spatial autocorrelation (low values tend to have neighbours with high values and vice versa), values near 0 indicate no spatial autocorrelation (no spatial pattern - random spatial distribution) and values in the interval (0,1) indicate positive spatial autocorrelation (spatial clusters of similarly low or high values between neighbour municipalities should be expected.)

Value

Returns the weights matrix, the calculated Moran's I and a list of statistics for the latter's inference: the expected I (E[I]), z scores and p values for both resampling and randomization null hypotheses.

`W` Weights Matrix

`Morans.I` Classic global Moran's I statistic

`Expected.I` The Expected Moran's I (E[I]=-1/(n-1))

`z.resampling` The z score calculated for the resampling null hypotheses test

`z.randomization` The z score calculated for the randomization null hypotheses test

`p.value.resampling` The p-value (two-tailed) calculated for the resampling null hypotheses test

`p.value.randomization` The p-value (two-tailed) calculated for the randomization null hypotheses test

Note

This function has been compared to the function Moran.I within the file MoranI.R of package ape version 3.1-4 (Paradis et al., 2014). This function results in the same Moran's I statistic as the one in package ape. The statistical inference in the latter refers to the randomization null hypotheses test discussed above. It is necessary to acknowledge that the code of this function has been assisted by the one in ape package: this is the calculation of statistics S1 and S2 (lines 67 and 69 of the source code) in this function. Another R package with functions for calculating and testing the Moran's I statistic and its significance is the spdep package (Bivand et al. 2014). The Moran's I statistic calculated using this function is not the same as the one in OpenGeoDa (Anselin et al., 2005). The latter is another very popular software for calculating spatial autocorrelation statistics.

Author(s)

Stamatis Kalogirou <skalo@hua.gr>

References

Anselin, L., I. Syabri and Y Kho. ,2005, GeoDa: An Introduction to Spatial Data Analysis. Geographical Analysis 38(1), 5-22.

Bivand et al., 2014, spdep: Spatial dependence: weighting schemes, statistics and models, http://cran.r-project.org/web/packages/spdep/index.html

Cliff, A.D., and Ord, J.K., 1973, Spatial autocorrelation (London: Pion).

Cliff, A.D., and Ord, J.K., 1981, Spatial processes: models and applications (London: Pion).

Goodchild, M. F., 1986, Spatial Autocorrelation. Catmog 47, Geo Books.

Moran, P.A.P., 1948, The interpretation of statistical maps, Journal of the Royal Statistics Society, Series B (Methodological), 10, 2, pp. 243 - 251.

Moran, P.A.P., 1950, Notes on continuous stochastic phenomena, Biometrika, 37, pp. 17 - 23.

Kalogirou, S., 2003, The Statistical Analysis And Modelling Of Internal Migration Flows Within England And Wales, PhD Thesis, School of Geography, Politics and Sociology, University of Newcastle upon Tyne, UK. URL: https://theses.ncl.ac.uk/dspace/handle/10443/204

Paradis et al., 2014, ape: Analyses of Phylogenetics and Evolution, http://cran.r-project.org/web/packages/ape/index.html

Examples

```
data(GreeceNew)
Coords<-cbind(GreeceNew$X, GreeceNew$Y)
Bdw<-6
x<-GreeceNew$UnemplRate
mI<-moransI(Coords,Bdw,x)

mI$Morans.I
mI$Expected.I
mI$z.resampling
mI$p.value.resampling
mI$z.randomization
mI$p.value.randomization
```

---

spGini *Spatial Gini coefficient*

Description

This is the implementation of the spatial decomposition of the Gini coefficient introduced by Rey and Smith (2013). The function calculates the global Gini and the two components of the spatial Gini: the inequality among nearest (geographically) neighbours and the inequality of non-neighbours. Three weighted schemes are currently supported: binary, bi-square and row standardised bi-square.

Usage

```
spGini(Coords, Bandwidth, x, WType = "Binary")
```

Arguments

`Coords`	a numeric matrix or vector or dataf rame of two columns giving the X,Y coordinates of the observations (data points or geometric / population weighted centroids)
`Bandwidth`	a positive integer that defines the number of nearest neighbours for the calculation of the weights

x	a numeric vector of a variable
WType	string giving the weighting scheme used to compute the weights matrix. Options are: "Binary", "Bi-square", "RSBi-square". Default is "Binary". Binary: weight = 1 for distances less than or equal to the distance of the furthest neighbour (H), 0 otherwise; Bi-square: weight = (1-(ndist/H)^2)^2 for distances less than or equal to H, 0 otherwise; RSBi-square: weight = Bi-square weights / sum (Bi-square weights) for each row in the weights matrix

Value

Returns a list of three values Gini=gGini,gwGini=gwGini,nsGini=nsGini

Gini	Global gini
gwGini	First component of the spatial Gini: the inequality among nearest (geographically) neighbours
nsGini	Second component of the spatial Gini: the inequality among non-neighbours

Author(s)

Stamatis Kalogirou <skalo@hua.gr>

References

Rey, S.J., Smith J.S., 2013, A spatial decomposition of the Gini coefficient, Letters in Spatial and Resource Sciences, 6 (2), pp. 55-70.

Examples

```
data(GreeceNew)
Coords1<-cbind(GreeceNew$X, GreeceNew$Y)
Bandwidth1<-12
x1<-GreeceNew$UnemplRate
WType1<-'Binary'
spGini(Coords1,Bandwidth1,x1,WType1)
```

VotesGR — *New Democracy and Total Votes in Greece in 2012*

Description

New Democracy and Total Votes per prefecture in the double parliamentary elections in Greece in May and June 2012, respectively

Usage

```
data(VotesGR)
```

Format

A data frame with 51 observations on the following 8 variables.

`MapCode2` a numeric vector of codes for joining this data to a map

`NAME_ENG` a alphanumeric vector of prefecture names in greeklish

`X` a numeric vector of x coordinates

`Y` a numeric vector of y coordinates

`NDJune12` a numeric vector of votes for New Democracy in June 2012 parliamentary elections

`NDMay12` a numeric vector of votes for New Democracy in May 2012 parliamentary elections

`AllJune12` a numeric vector of total valid votes in June 2012 parliamentary elections

`AllMay12` a numeric vector of total valid votes in May 2012 parliamentary elections

Details

The X,Y coordinates refer to the geometric centroids of the 51 Prefectures in Greece in 2011. All electoral districts in the Attica Region have been merged to one. The two electoral regions in Thessaloniki have also been merged to a single region matching the NUTS II regions geography.

Source

The shapefile of the corresponding polygons is available from the Public Open Data of the Greek Government at http://geodata.gov.gr/geodata. The election results (votes) are available from the Hellenic Ministry of Interior at http://www.ypes.gr/en/Elections/NationalElections/Results/.

References

Paper in preparation to be presented in the 10th International Congress of the Hellenic Geographical Society, Thessaloniki, 22-24/10/2014

Examples

```
data(VotesGR)
plot(VotesGR$NDJune12,VotesGR$NDMay12)
abline(0,1)
```

Index