spatial statistics with geoda

adam okulicz-kozaryn

adam.okulicz.kozaryn@gmail.com

this version: Wednesday 11th October, 2023 14:06

outline

geoda basics and visualizations

spatial statistics intuition [wordy/lengthy: no time for this; do quick version posted on syllabus instead]

spatial weights

using spatial weights

K-means, medians etc DEFINITELY DO NEXT TIME

presentations

- volunteers?

reference

- `https://geodacenter.github.io`
- there are tutorials and data for practice:
  - `https://geodacenter.github.io/documentation.html`
  - `https://geodacenter.github.io/data-and-lab/`

why another software?

- because geoda is unique!
- it's not full-fledged gis software like qgis
  - but can have multiple maps/figures and they're linked
- and it can do spatial statistics
- let's start with visualizations

outline

geoda basics and visualizations

spatial statistics intuition [wordy/lengthy: no time for this; do quick version posted on syllabus instead]

spatial weights

using spatial weights

K-means, medians etc DEFINITELY DO NEXT TIME

let's fire it up

- start-search for-"geoda"
- the main visual difference with qgis are:
  - geoda has only top menu/icons
  - can do many maps and figures at the same time

first, let's get some data

- again, lots of datasets at

  `https://geodacenter.asu.edu/sdata`

- get columbus data

  - `http://geodacenter.org/downloads/data-files/columbus.zip`

- and unzip somewhere

and load to geoda

- File-New Project-Input file-'open file icon'-ESRI Shapefile
- and navigate to wherever you have unzipped columbus data
- so we have neighborhoods in columbus
- there is 'Open Table' icon, just below of 'Table' menu
- like in qgis, can select u/a either in table or in map

Table menu

- again, typical things that you have already seen in qgis
- merging, variable calculator, etc
  - can use those instead of those in qgis if you like...
- but typical gis (what we have done so far) works little better in qgis
- here, we'll focus on what qgis cannot do:
  - visualization
  - spatial stats

histogram (again, always have it for your key var!)

- Explore-Histogram
  - and select INC (income)
- okay, we got a histogram
  - but it is a super histogram!
- can right-click and save-as, change num of int, etc
- we've got a range for each bin
  - num of obs for each bin
- really cool: click bar to highlight features in the map!
  - and can rectangle select more than one bin
- typical city: poor in the middle; rich on the fringe

thematic map–quick and easy

- Map-Themeless Map is just another map
  - note: can have several maps at the same time
- Map-Quantile Map, do '5', 'INC'; just like qgis
- again, note: everything is linked–click class in quantile map and it will highlight in both thematic and themeless map
- Map-Percentile Map: good for detecting outliers/extremes
  - compare it with quintile map
  - even though none in top/bottom 1%, there are 5 in each top/bottom 10%

more about thematic maps

- Map-Unique Values Map would be good for categorical var
- yet, it does some clustering into bins
- kind of like 'categorized' (not 'graduated') ramp in qgis

more about thematic maps

- Map-Cartogram
- circle size=CRIME; circle color=INC
- in general hi income is low crime;
- but note little blue circle in top left: low inc, low crime
- i don't like it, i'm old fashioned
- try other things in map menu
  - explore, use them–convince me to nonstandard maps!
  - as long as it makes sense, and you can explain it, it's great!

Explore-Scatter Plot

- like in regular, non-GIS stats package
- do INC against CRIME, as expected negative relationship
- note that obs with low income and crime
  - rectangle-select it

    aha same place as we identified in cartogram
- very interesting to both correlate and map
- a great addition to your final project
- rectangle selecting a subset gives you an idea of slope

  change!
  - say lets just select in map western columbus–slope is flat

outline

geoda basics and visualizations

spatial statistics intuition [wordy/lengthy: no time for this; do quick version posted on syllabus instead]

spatial weights

using spatial weights

K-means, medians etc DEFINITELY DO NEXT TIME

why spatial statistics?

- sounds scary...there is word 'statistics'
  - but we'll only do maps and graphs
  - no formulas, no calculations–relax!
- all we will do is just correlation in space
- so called spatial autocorrelation
- and formally calculated with Moran's I
  - or Local Moran's I (LISA)

correlation

- everyone heard of correlation, right? what is it?

  examples?

- many things correlate positively; people in space, too
- fat people like fat people; smokers like smokers, etc
- in short people you spend time with, are like you...
  - `http://nicholaschristakis.net/wp-content/uploads/2015/03/Spread-of-Alcohol-Consumption-Behavior-in-a-Large-Soci pdf`
  - (last page)
  - `http://kelsocartography.com/blog/wp-content/uploads/2008/05/gr2008052600099.gif`
  - `https://www.google.com/search?q=christakis+fowler+obesity&tbm=isch`

same about anything in space

- `http://www.thebigsort.com/maps.php`
- hi-crime neighborhoods next to hi-crime neighborhoods
- poor blocks next to poor blocks
- even poor states are next to poor states (Mississippi, Alabama, etc)
- poor countries cluster together, too: Africa, Latin America, etc
- in short, things/areas that are close to each other in space are alike

the first law of geography

- The first law of geography according to Waldo Tobler is:
- "Everything is related to everything else,
- but near things are more related than distant things"
- keep this in mind! it's almost always true!
  - do you see this in your research?

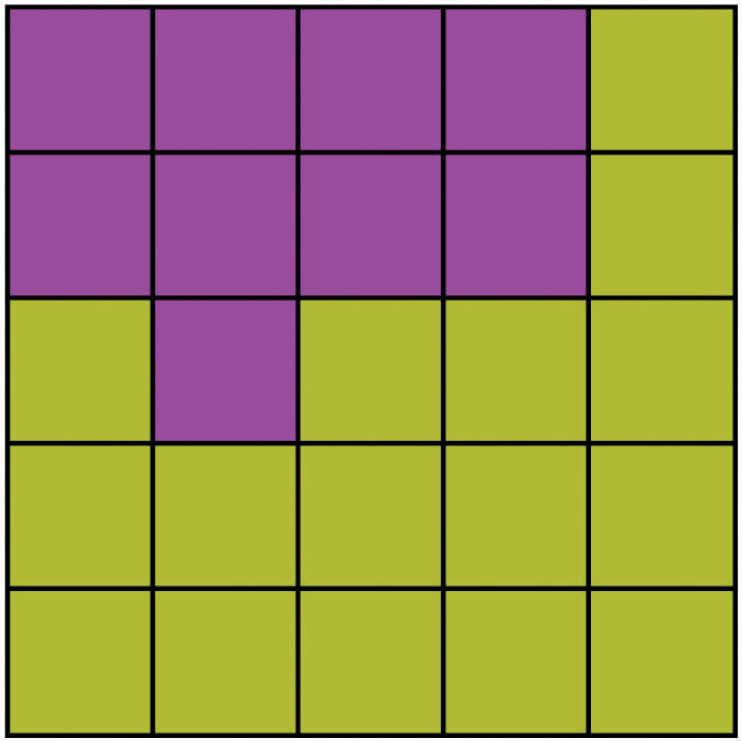
positive v negative spatial autocorrelation

- note: autocorrelation
- correlate values of a var with values of the same var
- how?
- we spatially lag a variable (details in next section)
  - and we correlate value of that variable with
  - average value of the same variable in nearby polygons
- positive if similar values next to each other
- negative if dissimilar values next to each other
  - details in next section, but can already see it in plain thematic maps

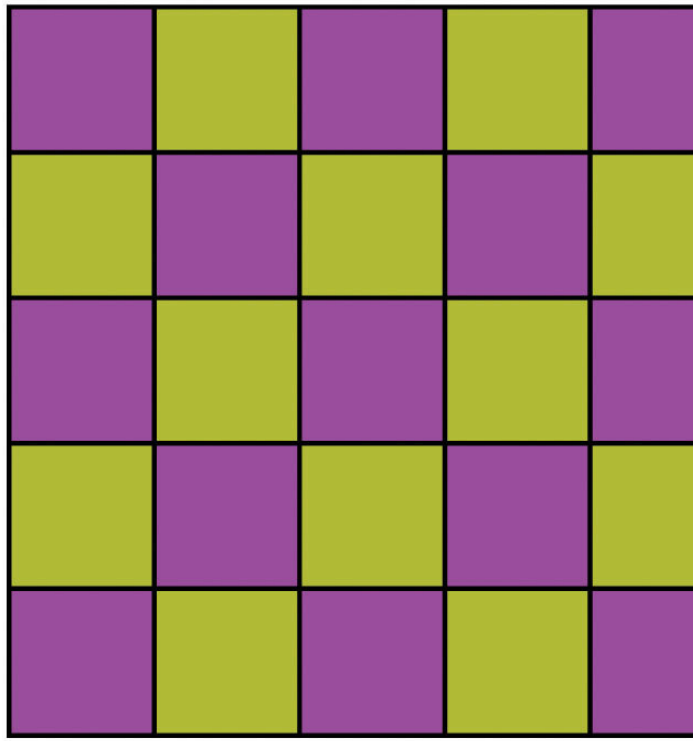
pos and neg

◇

POSITIVE : Pattern of Similarity



NEGATIVE : Pattern of Dissimilar



negative correlation is even more interesting

- less common than positive correlation: it's more interesting
- (usually anything less common is more interesting)
- eg sometimes you will see rich area in the middle of poverty
- etc

application: my paper about happiness in Europe

- https://sites.google.com/site/adamokuliczkozaryn/pubs/gesis3.pdf
  - see histogram and maps
- positive spatial autocorrelation
- clusters of happy and unhappy provinces
  - and they span across country boundaries
  - it is interesting to identify them and formally test it

just a thematic map

- you'll already see or at least sense
  - spatial correlation from regular thematic maps
- just have a close look, and think about it
  - discuss in ps6, paper
- and now we'll use geoda to formally test if there is correlation

outline

geoda basics and visualizations

spatial statistics intuition [wordy/lengthy: no time for this; do quick version posted on syllabus instead]

spatial weights

using spatial weights

K-means, medians etc DEFINITELY DO NEXT TIME

the first step

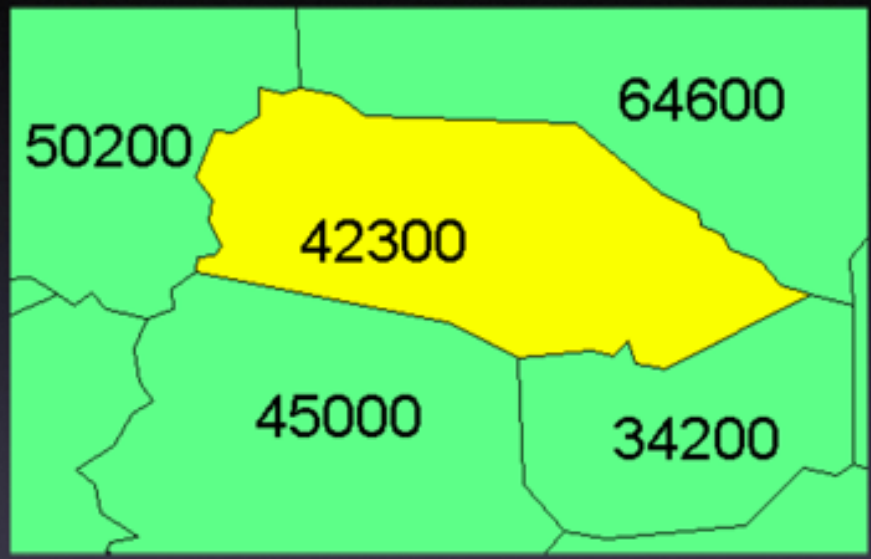
- the first step before producing spatial corr
- is to produce spatial weights
- or spatially lag a variable

we will spatially lag a variable

- it's like time lagging a variable draw a var and its lag
  - time lagging is useful in exploring temporal precedence
  - eg you may want to know what is the corr/effect of unemployment last year on this year's poverty
- spatially lagged var: want to know the relationship of
- a place to its neighbors
- spatially lagged variable is just
  - an average of values for its neighbors
- for elaboration see ex17 'spatially lagged vars' p124 of geoda workbook

`https://geodacenter.asu.edu/system/files/geodaworkbook.pdf`

Spatial Lag Example



Average Neighbor Land Values

1/4x50200 + 1/4x45000 + 1/4x34200 + 1/4x64600

Spatial Lag Example

1 7	2 6	3 4
4 4	5 5	6 4
7 5	8 6	9 3

Sample Region and Units

- Spatial lag = sum of spatially-weighted values of neighboring cells
  = 1/3(7) + 1/3(5) + 1/3(4)
  = 5.3

let's do it! create weights

- Tools-Weights-Create
- Weights File ID Variable: POLYID
  - usually fips or some unique ID/KEY var identifier of a place
  - (i think it must be numeric)
- and now the key part: defining neighbors
- who is a neighbor?

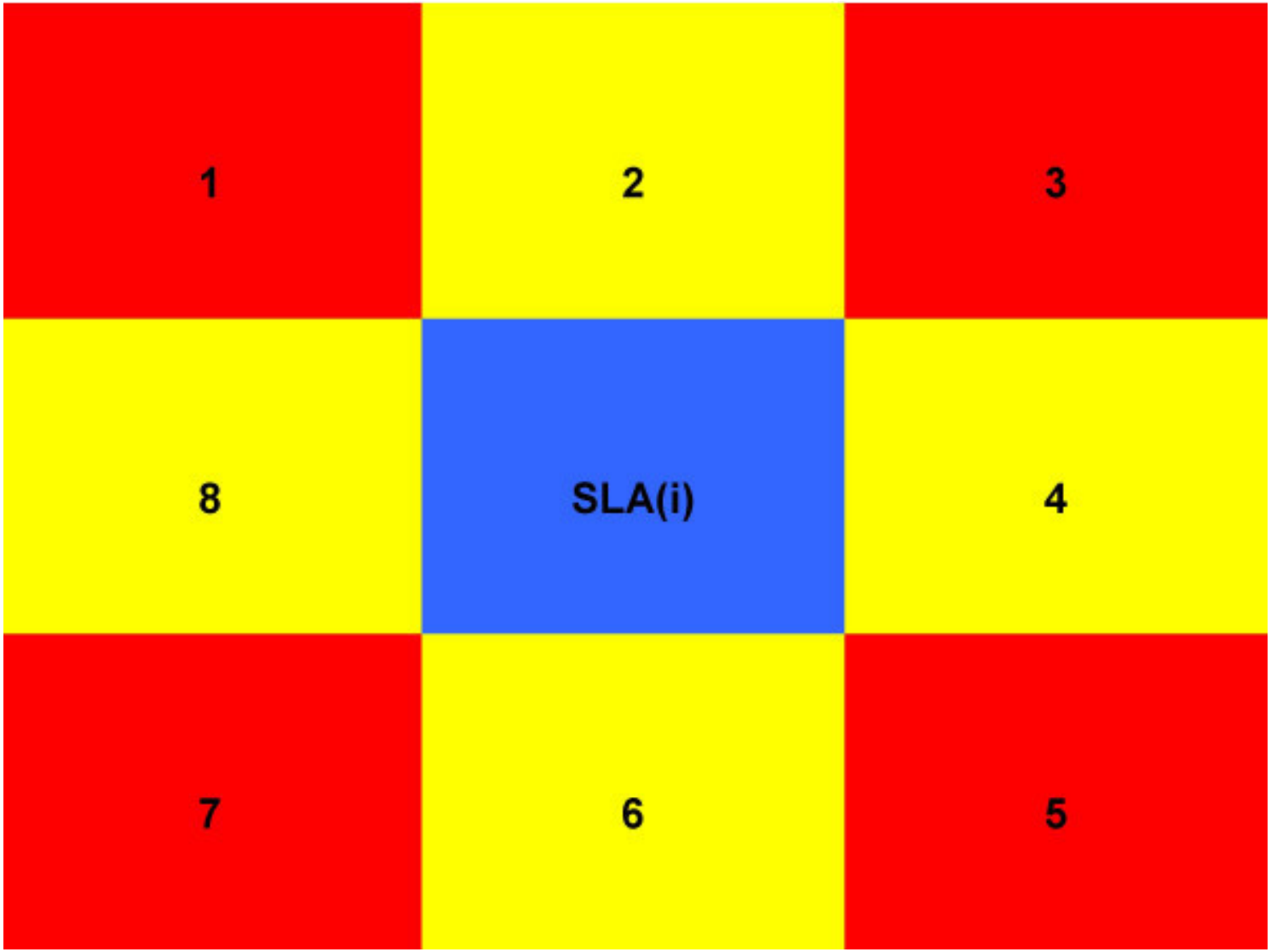
2 ways

- contiguity based (we'll just do these):
  - neighbor of place A touches on place A
- distance based: neighbor of place A is within some distance of place A

2 types of contiguity weights

- usually just pick queen contiguity–neighbor is any place that neighbors our place
  - at least must share a vertex, say North, North-East, etc
- can do rook: must share a border, not just vertex
  - so *not* North-East

rook v queen



- Rook: only 2,4,6, 8; Queen: all (i.e. 1-8)

order of contiguity

- in geoda can choose higher orders
- i.e. neighbors of my neighbors are my neighbors...
- we'll just stick with 1st order
- for more info and elaboration:
  - `https://geodacenter.asu.edu/node/380`

save it

- note it will create a file with extension .gal
- it's just a text file; let's explore it in text editor
- Start button- and search for 'notepad' and fire it up
  - navigate to where you saved .gal file
  - make sure you select 'all files' at bottom-right
  - and open .gal file

exploring gal file

- line 2: '1 2': POLYID 1 has 2 neighbors
- l3: '2 3' and these neighbors are POLYID 2,3
- l4: '2 3': POLYID 2 has 3 neighbors
- l5: '4 3 1' and these are POLYID 4,3,1
- and so on
- do not trust anybody
- let's look them up with table and highlight
- and confirm in map that indeed this is the case !

outline

geoda basics and visualizations

spatial statistics intuition [wordy/lengthy: no time for this; do quick version posted on syllabus instead]

spatial weights

using spatial weights

K-means, medians etc DEFINITELY DO NEXT TIME

reference

- again, see geoda workbook's appropriate chapter

  `https://geodacenter.asu.edu/system/files/geodaworkbook.pdf` [detailed, but dry]

- a very brief overview

  `https://geodacenter.asu.edu/system/files/SA_Concept_Demo.pdf` [very good!]

got weights?

- in previous sec, we have created weights...
- make sure you have them selected:
- Tools-Weights-Select: 'Select from currently used'
  - should point to your .gal file

Moran's I

- it's a basic spatial statistic
- just like regular correlation (from -1 to 1)
- Space-Univariate Moran's I: CRIME
- and it's .5 meaning that
  - there is a moderate positive spatial autocorr in CRIME
- we've expected that from thematic map
- note that y-axis is lagged crime
- select some obs and discuss: its and its nei crime
  - see in a map; select some other obs that is diff

Moran's I

- i can also rectangle select points in scatterplot
- let' select those in top-right (hi-hi): central city
- now bottom-left (lo-lo): outer areas
- now outlier in top-left (lo-hi: low crime but hi crime around)
- let's look back at thematic map–indeed that place is low crime
  - but its neighbors are high crime
- there isn't a clear outlier with hi-lo at bottom right

Moran's I: HOVAL

- how about housing value (HOVAL)
- make thematic map and Moran's scatter plot
- much less clear clustering, and few hi-lo, lo-hi
- highlight them in scatter and compare in thematic map

LISA

- LISA is a Local Moran's I
- Space-Univariate Local Moran's I: CRIME
  - and select all three maps
- it nicely identifies clusters
- again, compare with thematic map

application

- https://sites.google.com/site/adamokuliczkozaryn/pubs/gesis3.pdf
  - see Moran's I scatterplot
  - http://people.hmdc.harvard.edu/~akozaryn/myweb/papers/gesis/
  - see output from Geoda online

so what?

- Moran's I and LISA help make sense of thematic maps
- they identify patterns, clusters, outliers
- very useful !
- e.g. is poverty concentrated ? etc etc
- I would be really happy if I see them in final project
- likewise, histograms are very nice for paper...
- and histogram for your key variable is necessary
  - (don't forget about interpretation!)
  - (don't ever show anything that you don't interpret)

so what?

- and it does matter where in the cluster one is located
- eg being poor in the middle of poverty may be better
- than being poor next to rich
- suicide among females in rural china:
  - not absolute but relative deprivation

we're doing space, but think about time, too

- not only focus on location of greatest poverty, crime etc
- over-time changes matter, too
- greatest or smallest increase
- largest change from well-established trend
- trend
- etc
- show 2 maps, say 1950 map next to 2000 map
- or calculate new var (2000-1950)/1950

outline

geoda basics and visualizations

spatial statistics intuition [wordy/lengthy: no time for this; do quick version posted on syllabus instead]

spatial weights

using spatial weights

K-means, medians etc DEFINITELY DO NEXT TIME