

Introduction of geospatial data visualization and geographically weighted regression (GWR)

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Study Background

- (1) Information of breast cancer or population characteristic such as mortality rate, median household income, and ethnicity ...etc around Nashville area or US.

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- (1) Information of breast cancer or population characteristic such as mortality rate, median household income, and ethnicity ...etc around Nashville area or US.
- (2) Data are summarized in different levels.
 - ▶ State
 - ▶ County
 - ▶ Zip Code
- (3) The goal is generating several geographic maps with color representing information of interests.

Tennessee

Zip Code	Zip City	County	Female Mortality Rate per 100K
37013	Antioch	Davidson	20.05
37072	Goodlettsville	Davidson	28.13
37076	Hermitage	Davidson	25.34
37080	Joelton	Davidson	29.39
37115	Madison	Davidson	31.52
37138	Old Hickory	Davidson	28.71
37189	Whites Creek	Davidson	34.24
37201	Nashville	Davidson	27.40
.	.	.	.
.	.	.	.
.	.	.	.

Tasks

- ▶ Generate a color scale
How to represent, for example mortality rate, in a map with color ?

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Where to get information or R functions to plot the map ?
- ▶ Fill in the color
Who is who ?

Get Colors

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color.scales <- colorRampPalette(c("orange", "red"))  
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- ▶ `col.lists`

```
"#FFA500" "#FF8D00" "#FF7500" "#FF5E00"  
"#FF4600" "#FF2F00" "#FF1700" "#FF0000"
```

Get Colors

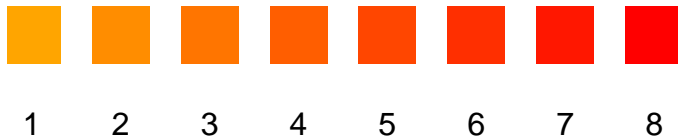
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```
"#FFA500" "#FF8D00" "#FF7500" "#FF5E00"  
"#FF4600" "#FF2F00" "#FF1700" "#FF0000"
```
- ▶ It's called hexadecimal color codes.
There are also RGB color function in R available.

```
rgb(228,26,28,max=255)
```

8 Levels Between Orange and Red



More Colors ?!?!

- ▶ Can we get more than two colors and have the scales between all of them ?

More Colors !?!?

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- ▶ Usage :

```
color.scales <- colorRampPalette(c("orange", "red", "green"))  
col.lists <- color.scales(21)
```



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Zip Code Boundaries

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Formal class 'SpatialPolygonsDataFrame' [package 'sp'] with
5 slots
..@ data : 'data.frame': 964 obs. of 8 variables:

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..@ data :'data.frame': 964 obs. of 8 variables:
- ▶ and another 1277 more lines !!!

Structure of .shp File

```

Formal class 'SpatialPolygonsDataFrame' [package "sp"] with 5 slots
..@ data :'data.frame': 964 obs. of 8 variables:
.. ..$ AREA : num [1:964] 2.92e-03 2.34e-02 4.18e-03 2.02e-05 2.95e-05 ...
.. ..$ PERIMETER : num [1:964] 0.8641 1.3754 2.9457 0.0226 0.0326 ...
.. ..$ ZT47_D00_ : int [1:964] 2 3 4 5 6 7 8 9 10 11 ...
.. ..$ ZT47_D00_I: int [1:964] 1 2 3 4 5 6 7 8 9 10 ...
.. ..$ ZCTA : Factor w/ 634 levels "37010","37012",...: 65 66 65 15 15 15 88 108 81 98 ...
.. ..$ NAME : Factor w/ 634 levels "37010","37012",...: 65 66 65 15 15 15 88 108 81 98 ...
.. ..$ LSAD : Factor w/ 1 level "Z5": 1 1 1 1 1 1 1 1 1 ...
.. ..$ LSAD_TRANS: Factor w/ 1 level "5-Digit ZCTA": 1 1 1 1 1 1 1 1 1 ...
.. -- attr(*, "data.types")= chr [1:8] "F" "F" "N" "N" ...
..@ polygons :List of 964
.. ..$ :Formal class 'Polygons' [package "sp"] with 5 slots
.. .. ..@ Polygons :List of 1
.. .. .. ..$ :Formal class 'Polygon' [package "sp"] with 5 slots
.. .. .. .. .. labpt : num [1:2] -88 36.6
.. .. .. .. .. area : num 0.00292
.. .. .. .. .. hole : logi FALSE
.. .. .. .. .. ringDir: int 1
.. .. .. .. .. coords : num [1:169, 1:2] -88 -88 -88 -88 -88 ...
.. .. .. .. .. plotOrder: int 1
.. .. .. .. .. labpt : num [1:2] -88 36.6
.. .. .. .. .. ID : chr "0"
.. .. .. .. .. area : num 0.00292
  
```


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 - ▶ Main parts with numbers of small boxes inside.
 - ▶ Coordinates.

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 - ▶ Coordinates.
 - ▶ Center Coordinate.

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 - ▶ The other 3 median boxes which is not so important.

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- ▶ Assumption : the zip code is saved with the order.

Plot the Shape & Colored Only by Coordinates

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- ▶ If can handle the color as wellll will be better.
- ▶ *polygon{graphics}*
- ▶ Usage :
*polygon(x, y = NULL, density = NULL, angle = 45,
border = NULL, col = NA, lty = par("lty"),...)*

Representing Information with Colors

Zip Code	Female Mortality Rate per 100K	20% Quantile
37013	20.05	1
37072	28.13	4
37076	25.34	3
37115	22.52	2
37138	28.71	5
37189	34.24	5
37201	27.40	4
.	.	.
.	.	.
.	.	.

Representing Information with Colors

Zip Code	Female Mortality Rate per 100K	20% Quantile	Corresponding Color
37013	20.05	1	#9999FF
37072	28.13	4	#4C4CFF
37076	25.34	3	#6666FF
37115	22.52	2	#7F7FFF
37138	28.71	5	#3333FF
37189	34.24	5	#3333FF
37201	27.40	4	#4C4CFF
.	.	.	.
.	.	.	.
.	.	.	.

Two Parts of Data

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- ▶ Now we are ready to plot !!!!

Geographically Weighted Regression

Quantile Regression & Geographically Weighted Quantile Regression
Discussion

GWR

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GWR

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 - ▶ What if we have more or fewer data points ?
 - ▶ Simple correlation can't deal with multiple covariates at the same time.

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- ▶ My first idea : Spearman's correlation.
- ▶ The problem are :
 - ▶ What if we have more or fewer data points ?
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- ▶ Brunson (1996), "Geographically Weighted Regression: A Method for Exploring Spatial Nonstationarity", Geographical analysis, Vol. 28, No. 4, P.281.

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- ▶ It might be more reasonable to assume that rates of change are determined by local culture or local knowledge, rather than a global utility assumed for each commodity.
- ▶ Variations in relationships over space, such as those described above, are referred to as spatial nonstationarity.

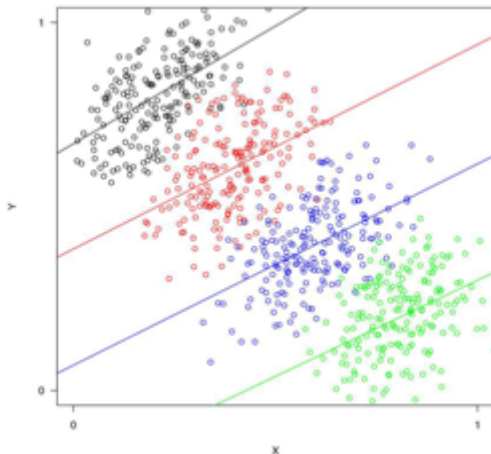
GWR

- ▶ Wherever a house is located, for example, the marginal price increase associated with an additional bedroom is fixed.
- ▶ It might be more reasonable to assume that rates of change are determined by local culture or local knowledge, rather than a global utility assumed for each commodity.
- ▶ Variations in relationships over space, such as those described above, are referred to as spatial nonstationarity.
- ▶ Simple linear model is not not appropriate, but widely used in early 90s for the data with geographic information.

Geographically Weighted Regression

Quantile Regression & Geographically Weighted Quantile Regression
Discussion

Simpson's Paradox



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► $y = \alpha + \beta X + \epsilon$

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- ▶ $y_i = \alpha_i + \beta_i X + \epsilon_i$
- ▶ Where i indicates that there is a set of coefficients estimated for every observation in the data set.

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- ▶ Where i indicates that there is a set of coefficients estimated for every observation in the data set.
- ▶ Key difference : We estimate a set of regression coefficients for each observation (i).
- ▶ To do so we weight near observations more heavily than more distant ones.
- ▶ First law of geography: everything is related with everything else, but closer things are more related.

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GWR

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- ▶ Bandwidth specifies shape of weights curve.

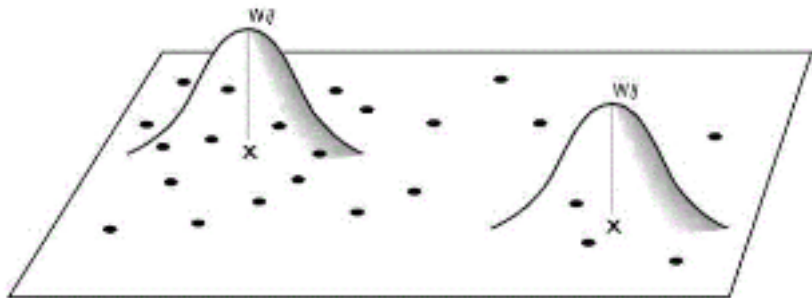
GWR

- ▶ Decide how you are going to weight your nearby locations.
 - ▶ Fixed bandwidth
 - ▶ Variable bandwidth
 - ▶ User-defined bandwidth
- ▶ Bandwidth specifies shape of weights curve.
- ▶ Whether we will define our bandwidth based on distance (fixed) or number of neighbors (adaptive).

Geographically Weighted Regression

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Fixed Bandwidth

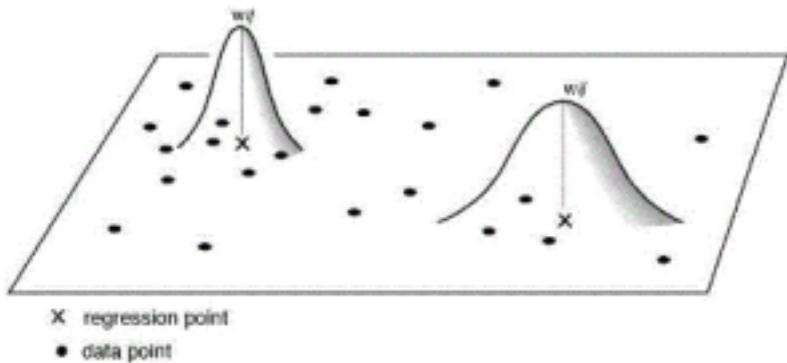


- ✕ regression point
- data point

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Adaptive Bandwidth



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- ▶ data(columbus)
- ▶ 5 variables
 - ▶ crime - recorded crime per inhabitant
 - ▶ income - average income values
 - ▶ housing - average housing costs
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 - ▶ crime - recorded crime per inhabitant
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 - ▶ housing - average housing costs
 - ▶ x - latitude
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- ▶ Relationship between crime and income & housing.

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 - ▶ `formula`, `data`, `coords`.
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 - ▶ `formula`, `data`, `coords`.
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- ▶ Returns the cross-validation bandwidth.

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 - ▶ An example.

QR & GWQR

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- ▶ Quantile regression is also a method that could be applied to spatial data.
- ▶ Another regression method called Geographically Weighted Quantile Regression (GWQR), as well as the corresponding R package are under development.
- ▶ By integrating the features of QR into GWR, the GWQR permits researchers to investigate the spatial non-stationary across both space and the whole distribution of a dependent variable.

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- ▶ Thank you !! & Questions ??