

Data Solutions for the Modern Metropolis



Intermediate GIS with QGIS and

PostGIS

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Follow along: http://bit.ly/dot_intermediate_gis2

www.datapolitan.com

Goals for the class

- Provide a review of key spatial concepts and GIS functions in QGIS
- Demonstrate connecting to a spatial database in QGIS
- Introduce the structured query language (SQL) for querying relational databases
- Practice writing queries in SQL to accomplish key spatial analytical tasks with real-world data to answer meaningful analytical questions
- Practice best practices in communicating spatial analysis

Outcomes

- You will feel more comfortable with GIS concepts
- You will be more familiar with using QGIS
- You will understand the purpose of spatial databases
- You will have an understanding of the fundamentals of SQL
- You will be familiar with advanced styling techniques in QGIS

Goals for this morning

- Review basic geospatial principles
- Practice performing basic spatial operations in QGIS
- Discuss spatial databases
- Demonstrate and practice loading data from a spatial database in QGIS
- Practice answering an operational question with spatial data
- Demonstrate and practice more advanced styling techniques in QGIS

Basic Spatial Elements



Vector Polygon Feature



Source: http://docs.qgis.org/2.8/en/docs/gentle_gis_introduction/vector_data.html#overview

Geographic Information System (GIS)

- Create interactive queries (user-created searches)
- Analyze spatial information
- Edit data in maps
- Present the results of all these operations

"Any system for capturing, storing, checking, and displaying data related to positions on the Earth's surface"

National Geographic Education Encyclopedia

"In a GIS, you connect data with geography."GISgeography.com

Adding Basemaps (QuickMapServices Plugin)

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		Tags: wms,qms,openstreetmap,internet,tms,basemap,mapquest,go More info: <u>homepage_tracker_code_repository</u> Author: NextGIS Available version: 0.16.2 (in QGIS Official Plugin Repository)					
		Upgrade all Install plugin					
	Help	Close					

Adding Base Maps (QuickMapServices Plugin)



Choosing a Base Map

- Think about what someone reading your map needs to see for context
- Think about how the base map interacts with the data on your map

Adding Layers



Shapefiles

- Basic file for storing map elements
- Stores spatial data, like points, lines, and polygons
- Multiple files comprise a "shapefile"
- Column names can only be ten characters long

Shapefile file components:

- .shp The main file that stores the feature geometry
- .dbf The dBASE table storing attribute information of features
- .prj The file that stores the coordinate system information
- .shx The index file that stores the index of the feature geometry
- .cpg—Identifies the character set to be used
- .sbn and .sbx—The files storing spatial index of the features

Layer Ordering

- Layers on top are drawn on top
- Just drag and drop within the Layers Panel to change order

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	🖭 nybb.shp	4/4/16 5:35 PM	XML Document	16 KB
2 2 2 2 3	nybb.shx	4/4/16 5:35 PM	SHX File	1 KB
	5 items Offline status: Online Offline availability: Not available			

Download and Import Shapefile in QGIS

1. Click this link (http://www.datapolitan.com/DOT_GIS/20160510_Intermediate_GIS/data/boros/

boros.zip) and download the file to your desktop

- 2. Unzip the file
- 3. Open in QGIS following steps below



Download and Import a CSV in QGIS

1. Right click this link: http://www.datapolitan.com/DOT_GIS/20160510_Intermediate_GIS/data/

dot_311_20160201_20160207.csv

2. Select "Save link as" Laver Settings Plugins Vector Raster Database Web MMOGIS Processing Help Create Layer 3. Save the file to your desktop ۲ M 🕅 🔟 Add Layer Vo Add Vector Layer... Ctrl+Shift+V Embed Layers and Groups... 🛃 Add Raster Layer... Ctrl+Shift+R Add from Layer Definition File... 🧠 Add PostGIS Layers... Ctrl+Shift+D Copy style 🌽 Add SpatiaLite Layer... Ctrl+Shift+L Paste style 腕 Add MSSQL Spatial Layer... Ctrl+Shift+M Open Attribute Table Add Oracle Spatial Layer... Ctrl+Shift+O Toggle Editing 💮 Add WMS/WMTS Layer... Ctrl+Shift+W Save Layer Edits 🗬 Add Oracle GeoRaster Layer... Current Edits Add WCS Layer... Save As... 🕼 Add WFS Layer... Save As Layer Definition File... Add Delimited Text Layer. . Remove Layer/Group Ctrl+D 🔀 Add Virtual Layer... 2 - X 💋 Create a Layer from a Delimited Text File File Name GIS/DOT_GIS/20160510 Intermediate_GIS/data/dot_311_20160201_20160207.csv Browse... Layer name dot_311_20160201_20160207 Encoding UTF-8 Ŧ File format CSV (comma separated values) Custom delimiters Regular expression delimiter Number of header lines to discard 0 ≑ 🗶 First record has field names Record options Field options Trim fields Discard empty fields Decimal separator is comma Geometry definition

Point coordinates Well known text (WKT)
 No geometry (attribute only table) X field Longitude ▼ Y field Latitude DMS coordinates Layer settings Use spatial index Use subset index Watch file ٠ Created Date Unique Key Closed Date Agency Agency Name 32574174 1 02/01/2016 12:06:44 AM 02/01/2016 06:48:33 AM DOT Department of Transportati 2 32570549 02/01/2016 12:12:00 AM 02/01/2016 01:15:00 AM DOT Department of Transportati 3 32572958 02/01/2016 12:14:00 AM 02/01/2016 12:54:00 AM DOT Department of Transportati Department of Transportati 4 32573576 02/01/2016 12:15:00 AM 02/01/2016 01:30:00 AM DOT 4 4 🕨 OK Cancel Help

Projections

- No one's favorite part of GIS
- But a necessary part of it nonetheless
- Convert points on the 3-dimensional Earth (latitude and longitude) to x and y coordinates on a 2-dimensional map
- Every projection distorts some part of your map
- For the most part we will work in WGS 84 (latitude and longitude)
- In NYC, we use a more accurate projection NY State Plane/Long Island Zone
- · Identified by unique IDs that make it easier to talk about them
- WGS 84 is referred to as EPSG:4326
- State Plane Long Island is referred to as EPSG:2263





Remember these two

and you should be set

Setting the Projection

- Filter by "4326"
- Select "WGS 84"
- Click "OK"

🌠 Coordinate Reference System Selector								
Specify CRS for layer Parking_Facilities								
	[
Filter	4326			×				
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The Result



Attribute Table (Right click on layer)



🔏 Attribute table - nybb :: Features total: 5, filtered: 5, selected: 0								
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3 1	Manhattan	358532.9564179	636442167.4670					
4 2	Bronx	464517.8905529	1186804144.789					
2 3	Brooklyn	726568.9463400	1959432236.829					
1 4	Queens	861038.4792990	3049947236.730					
0 5	Staten Island	330385.0369739	1623853249.910					
Show All Features								

Styling Features

- Right-click the layer and select the Properties option
- Select "Style," and finally, choose "Categorized"
- Select the column that has the data you want to style (from attribute table)
- 4. Select "Classify"
- 5. Click "Apply" and "Ok"



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Your turn

- Style the points and polygons however you'd like
- Try adding labels to the data
- Get familiar with the interface



Example map after styling boroughs with random colors

Spatial Databases

Database

- "An organized collection of data" Wikipedia
- Another source of data
- A program that often runs on a computer other than the one you're using (a server)
- You can connect to databases through many types of software, including QGIS

Spatial Database

- A database that stores spatial features
- Optimized for processing spatial data, especially location-aware queries
- Both a storage and analysis tool

Connecting to a spatial database

- Layer -> Add Layer -> Add PostGIS 1. Layers
- Under Connections, select "New" 2.

Schema

- Add connection information 3.
- Click to save username and 4 password
- Click "Test Connection" to 5. make sure everything is entered properly
- Click "OK" 6.
- Click "Connect" 7.
- Click on the tables you want to load and select 8. "bbA"

Now the data is just the same as any other data source (CSV, shapefile, etc)

Connection Information for class

- Name: (whatever you'd like)
- Host: training.c1erymiua9dx.us-east-1.rds.amazonaws.com
- Port: 5432
- Database: training
- Username: dot_student
- Password: qgis



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Exercise 1 - Selecting Injuries in a Borough

- Add the "injuries" table to your map
- Right click and select "Filter..."
- Select borough and query for your borough

TIP: Always test your queries to make sure they return resulting rows

OK

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Provider specific filter expression

"borough" = 'QUEENS'

Cancel

Clear

Test

• •

Help

Save Selected Features as a Shapefile





Database datatypes

- Like attribute tables, database columns have types
- Numbers, text (strings), and dates are the main types
- Spatial databases add geometry columns
- Geometry columns let us map our data

Why use a spatial database?

- One authoritative copy of data
- Multiple people can use and edit it at once
- Generally is going to be faster than using a shapefile

Drawbacks of using a spatial database

- Not as simple as a CSV file or shapefile
- It takes some setup to connect to a database
- Need permission to connect to a database
- Need to know SQL to get the most out of it

Types of Maps

General Reference Maps

- Show important physical features of an area
- Include natural and man-made features
- Usually meant to help aid in the navigation or discovery of locations
- Usually fairly simple
- Can be stylized based on the intended audience (tourists vs locals)



Thematic Maps

- Focuses on a specific theme or subject area
- Features on the map represent the phenomenon being mapped
- Spatial features used for reference



Basic Spatial Joins

- Point to Polygon -> Relate points inside a polygon to that polygon (ex. count the number of points)
- Polygon to Point -> Points can take on value of enclosing polygon

Exercise 2 - Which Community Boards in NYC have the highest number of bicyclist injuries?



NYC Community Board boundaries and bicyclist injuries

Gathering the data

- Add the "nyc_cd_4326" table
- Add the "injuries" table



Map of bicyclist injuries by NYC Community Board that we'll create

The Task

 Join injuries (points) to community districts (polygons)

Spatial Join steps

- 1. Vector->Data Management Tools->Join Attributes by Location
- 2. Select the target layer (the layer the attributes will go to)
- 3. Select the join layer (the layer attributes are taken from)
- 4. Select "Take summary of intersecting features", check "Sum"
- 5. Select the location for the shapefile
- 6. Select "Keep all records"
- 7. Click "OK"

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42	43	103	30356.50620920	46907648.25429	48,0000000000	
57	56	104	67931.82693130	49292600.89890	24.00000000000	
8	9	105	35287.62241340	43796763.41889	66.0000000000	
6	8	106	40626.73408339	38704874.05979	46.00000000000	
	52	107	39863.24147480	53154054.52440	23.00000000000	-
T	Show All Features					

Attribute table with successfully joined features





N	Join attributes by location
Target ve	ctor layer
nyc_cd_4	4326
Join vecto	or layer
injuries	
Attribut	e Summary ake attributes of first located feature
• Ta	ake summary of intersecting features 🗌 Mean 📄 Min 📄 Max 🗹 Sum 📄 Median
Output S	hapefile
/home/e	eric/Desktop/dot/nycd_injuries.shp Browse
Output	table
0 0	nly keep matching records
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Print Composer

8

Cancel

23

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- How you make exportable and printable maps in QGIS
- Able to add map elements (legends, scales, text, etc)

💋 Composer title

Create unique print composer title

(title generated if left empty)

OK

Creating a Print Composer

- 1. Select "New Print Composer"
- 2. Give it a title
- 3. Add elements to the blank canvas
- 4. Style elements









Draw Map Extent



Customize Item Properties

Add Text to Map

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X max 1	091272.662							
Y max 2	Y max 256998.707							
	Set to map canvas extent							
	View extent in map canvas							



Print Composer Problems

- Map extent -> "Use current map extent"
- Moving map around -> Adjust with arrows
- "North" arrow -> need to manually align

Exercise 3 - Which community board has the highest number of bicyclist injuries off of bicycle paths?



Bicyclist injuries, NYC bike routes, and Community Board boundaries

Steps to answer

- 1. Buffer bicyclist injuries (points)
- 2. Select injuries near bike lanes (intersection of

buffers with bike lane)

- 3. Invert the selection to find injuries that happened off of bike lanes
- 4. Count the number of injuries off of bike lanes by community boards
- 5. Style the result



Choropleth of bicyclist injuries off DOT bike routes by Community Board

Buffering features

- Gives "size" to 2-D features
- Points don't have area
- Lines have length but don't have width
- Allows for analysis of overlap and intersection



Step 0: Load the tables we need

- "injuries"
- "bike_routes_2015"
- "nyc_cd_2263"

Step 1: Buffering Features in QGIS

- 1. Vector -> Geoprocessing Tools -> Buffer(s)...
- 2. Select the layer you want to buffer on
- 3. Select the distance you want to buffer
- 4. Select the output shapefile
- 5. Click "OK"

SRID Map Units

- Each projection has a base unit of distance
- For WGS 84 it's decimal degrees
- Best to convert to a projection with simple map units
- For NYC, 2263 (NYS Plane Long Island Sound) is best (the map units are in feet)







Reprojecting Data

• Right click the "injuries" layer and select "Save As..."

Buffer your features again, this time using the reprojected layer

- Select the new projection (2263)
- Give the file a descriptive name
- Click OK

Buffered injuries

NOTE: we're saving data from the database locally on our computer when we reproject data this way



Selected buffers that intersect bike lanes

Step 2: Select injuries near bike lanes



Select by location in QGIS

- Select the buffered injuries layer
- Select "Intersects"
- Select the bike routes layer
- Select "Create new selection"
- Click "Apply"

QGIS will now find all the injuries that happened near or on a bike route and select just those features

Select source features from	Result feature ID's	
∽ injuries_2263_15_buffer ▼	Result query	-
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/here the feature	7 8	
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nd use the result to	44 49	
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	490 of 1389 identified	M
Selected features	Zoom to item	
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Step 3: Find injuries off of bike lanes

In the attribute table, select "Invert Selection"

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? X

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Apply

💋 Spatial Query

Select source features from

injuries_2263_15_buffer

Selected geometries

Reference features of

√[∞] bike_routes_2015

Selected geometries

Close

And use the result to

Create new selection

Where the feature Intersects

	X Save vector layer as
Save the inverted selection as it's own layer	Format ESRI Shapefile Save as njuries_2263_15_buffer_non_bike_route.shp Browse CRS Selected CRS (EPSG: 2263, NAD83 / New York Long Isl
	Encoding System Encoding System Skip attribute creation Add saved file to map Symbology export No symbology
	Scale 1:50000 Geometry Custom Options Custom Options
Result after inverting the selection	OK Cancel Help

Step 4: Join the result to the Community Boards (another spatial join)

🔏 Join attributes by location	? 🔀
Target vector layer	
nyc_cd_2263	-
Join vector layer	
injuries_2263_non_bike_path	-
Attribute Summary	
Take attributes of first located feature	
 Take summary of intersecting features 	
Mean Min Max 🕱 Sum Median	
Output Shapefile D:/Users/datapolitan/Documents/nycd_injuries_non_bike.shp Output table Only keep matching records	Browse
Keep all records (including non-matching target records)	
0% OK	Close

Step 5: Style the result



Your Turn

- Filter the result for your borough
- Style a map of just the community boards in your borough
- Develop a hypothesis as to why the injuries are happening in those areas

Goals for the Afternoon

- Discuss QGIS and other GIS tools
- Provide a basic understanding of open-source technology as it relates to GIS tools
- Introduce Structured Query Language for querying databases
- Practice using SQL for querying and processing spatial data
- Introduce heatmaps and practice creating them in QGIS

Proprietary vs Open Source Software

Open-Source software

- Free to download
- Free to use
- Able to change and customize
- Usually no enterprise support
- Supported by a community

SQL

- Structured Query Language
- The language databases understand

SQL Examples

SELECT *
FROM injuries

In english: "select all the injuries"

Proprietary software

- Pay to download
- Pay to use (usually with a license)
- Not able to change or customize (legally)
- Usually supported by a team of paid developer

SQL queries

- Can view data
- and change data
 We're going to stick to viewing data

SELECT *
FROM injuries
WHERE BOROUGH = 'QUEENS'

In english: "select all the injuries in Queens"

Combining conditions

SELECT *
FROM injuries
WHERE borough = 'QUEENS' AND contributi = 'Fatigued/Drowsy'

```
SELECT *
FROM injuries
WHERE contributi = 'Outside Car Distraction' OR contributi = 'Fatigued/Drowsy'
```

DB Manager

- One way to see your database connections and tables
- Also a way to run SQL queries on your tables

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Load Query Result as Layer

- Run query
- Select "Load as new layer"
- Identify the geometry column (should be "geom")
- Give the layer a prefix
- Select "Load now!"



Your turn

- Use DB Manager and SQL to select the injuries for the Bronx
- Add the results as a layer in QGIS

Spatial joins in SQL

- You can do the same spatial joins you would do in QGIS using SQL
- They give you more control than QGIS does
- And you don't have to create new shapefiles

Join Points to Polygons

- "Select all of the nyc_boro columns and the count of injuries"
- "Use the nyc_boro table"
- "Join with injuries, associate injuries with the nyc_boro they are within"
- "Count by borough"

SELECT nyc_boro.*, COUNT(injuries)
FROM nyc_boro
JOIN injuries ON ST_Within(injuries.geom, nyc_boro.geom)
GROUP BY nyc_boro.gid

Joining Tables in SQL

Database Schema Table	Inf	Fo SELE FROM JOIN GROU	Table Pre CT nyc_boro injuries ON JP BY nyc_	view & Quer Saved quer o.*, COUNT (inj I ST_WITHIN(inj boro.gid	y (Amazon AWS) 🗙 y: 💽 💌 Na uries) juries.geom,nyc_bc	me	Store	Dek	ete	injuries to boroughs, similar to what we did with QGIS for Community Boards
		xecute	(F5) 5 row	s, 0.8 seconds	Create a view			Cle	● ► ar	
	Г	gid	borocode	boroname	shape_leng	shape_area	geom	count		
	1	1	5	Staten Island	330385.0369739	1623853249.910	0106000020E61	9		
	2	2	4	Queens	861038.4792990	3049947236.730	0106000020E61	315		
	3	3	3	Brooklyn	726568.9463400	1959432236.829	0106000020E61	544		
	4	4	1	Manhattan	358532.9564179	636442167.4670	0106000020E61	375		
	5	5	2	Bronx	464517.8905529	1186804144.789	0106000020E61	146		
		Load	l as new layer							

ST_Within

- A spatial SQL function
- Similar to other SQL conditions (borough = 'QUEENS')
- We're checking whether the geometries of one table are within geometries from another

Spatial SQL functions

- There are many more you can use
- We're only covering ST_Within today
- But we will give you resources for finding other spatial SQL functions

Your turn

- Use DB Manager and SQL to do a points in polygon join to count injuries in community districts (table "nyc_cd")
- Add the results as a layer in QGIS
- Style the community districts by the number of injuries

Heatmaps

- One way of mapping density when you have many points
- An alternative to choropleth maps if you want to show a little more nuance

Heatmaps in QGIS

- Use the Heatmap plugin
- Create a raster (image) showing the density of the points
- Style the raster



ST_Within for different spatial objects



Source: http://a841-tfpweb.nyc.gov/bikeshare/ 2011/09/20/station-suggestion-recap/



Style dialogue for heatmaps



Your turn - Putting it all together

- Filter DOT 311 requests (dot_311) by borough and by type
- Join filtered requests to community districts
- · Create a choropleth of the number complaints in each community district
- · Create a heatmap of complaints in your borough
- You can do this in SQL or QGIS (your choice)
- We'll be around to help
- Hint: Be thinking about the problems we've run into with joining layers

Spatial data formats we didn't cover

- JSON and GeoJSON -> used for digital data exchange and online mapping applications
- XML and KML -> used by Google Earth and other Google-related mapping products

Geocoding (convert addresses to spatial locations)

- You'll want a CSV with the street address, city, and state in separate columns
- Enable the MMQGIS plugin

Resources

Books

Websites

- QGIS Map Design
- Learning QGIS 2.0
- PostGIS in Action
- http://postgis.net/documentation PostGIS documentation
- http://gis.stackexchange.com/ Online Q&A site for all things GIS
- http://docs.qgis.org/2.8/en/docs/ QGIS documentation
- http://www.qgistutorials.com/en/index.html Great tutorial site for QGIS
- https://anitagraser.com/ Great blog on QGIS features and news

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Reminders

- Know your layer projection
- Always test your queries when you filter
- Use descriptive filenames
- Keep your data organized
- Save your work often (especially your project file)
- When in doubt, save, close, and restart