QUERYING THE DATABASE, BOOLEAN OPERATORS, AND TOPOLOGICAL OVERLAY FUNCTIONS IN GIS (or, ‘Geoprocessing’)

Multiple Layer Operations

- How can we conceptualize “multiple layer” operations?
  - 2 Kinds:
    - Those that do not change the geometry of spatial data
    - Those that do change the geometry of spatial data, necessitating changes and updates to (vector) shapes
Multiple Layer Operations

- Multiple layer operations that do not change the geometry of spatial data
  - Select by Location
    - Spatial relationship is specified, spatial features are selected, but spatial data is not geometrically altered
  - Spatial Join
    - Data is appended from a “source” spatial data table to a “destination” spatial data table based on common location, again spatial data is not altered

Select by Location

- Relationships between layers (that you can specify):
  - Intersect
  - within distance of
  - Completely contain
  - Are completely within
  - Have their center in
  - Touch the boundary of
The GIS Data Model: Geographic Integration of Information

- Data is organized in layers, coverages or themes (synonymous concepts), with each theme representing some phenomena on the earth's surface.

- Layers are integrated using explicit location on the earth's surface, thus geographical location is the organizing principal.
The GIS Model: example

Here we have multiple layers:
- vegetation
- soil
- hydrology

They can be related because precise geographic coordinates are recorded for each layer.

Layers may be represented in two ways:
- in vector format as lines
- in raster format as pixels

Queries

- Aspatial Queries –
  - Querying the attribute data using commands

- Spatial Queries –
  - Querying the attribute data using the geography of other data
Aspatial Query in ArcGIS

- **Select by Attributes**

- **Build the SQL statement** by simply clicking and double-clicking

- **Check you SQL statement with the ‘Verify’ button**

- **Click ‘Apply’ then ‘OK’**

---

**Query – asking a question of the attribute data**

- **Standard Query Language (SQL) is used to query the data**

- **There are 4 basic statements used to get information from 2 (or more) datasets**

  - **AND** – if you are desiring the subset of each dataset that is ‘true’ of both datasets

  - **OR** – if you are desiring the subset of each dataset that is ‘true’ of either one or both datasets

  - **NOT** – if you are desiring the subset of one dataset that is only true of one dataset

  - **OR, BUT NOT BOTH (XOR)** – if you are seeking the subset of data that is ‘true’ of one and another dataset, but not both datasets
Querying the dataset databases can be done several different ways, but they always use the same type of query language.

**Boolean Operators:**

- **AND**
  - \( A \land B = \text{True if Both} \)

**Diagrams:**

- A and B are connected with an AND operator, indicating that both A and B must be true for the condition to be satisfied.
Boolean Operators: **AND**

$A \ AND \ B = \text{True if Both}$

---

Topological Overlay Operations

Querying the dataset databases can be done several different ways, but they always use the same type of query language.
Boolean Operators: OR

A OR B = True if one or other
Topological Overlay Operations

Querying the dataset databases can be done several different ways, but they always use the same type of query language.

Boolean Operators:

- **AND**
- **OR**
- **NOT**
- **XOR**

**A NOT B = True if Neither**
Boolean Operators: NOT

A NOT B = True if Neither

Topological Overlay Operations

Querying the dataset databases can be done several different ways, but they always use the same type of query language.
Boolean Operators: $A \ XOR \ B$

A OR B, but not both (XOR)
## Polygon on Polygon Vector Overlay Operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>INPUT LAYER 1</th>
<th>INPUT LAYER 2</th>
<th>OUTPUT LAYER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLIP</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>SELECT (NOT)</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>SPLIT</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>XOR</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>UNION</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>INTERSECT</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

**CLIP**
- Cuts out a piece of layer 1 using layer 2 as cookie cutter (1 AND 2)

**SELECT (NOT)**
- Erases (deletes) part of layer 1 using layer 2 (1 NOT 2)

**SPLIT**
- Splits 1 into many layers based on 2

**XOR**
- Layer 1 or 2, but not both (1 XOR 2)

**UNION**
- Overlays polygons and keeps all of both (1 OR 2)

**INTERSECT**
- Overlays but keeps only portions of layer 1 that fall within layer 2 (1 AND 2)

---

### Conceptual Design: Overlay Operations

In this design, each data set is represented by a circle:

![Diagram](image-url)
Multiple Layer Operations

- How can we conceptualize “multiple layer” operations?
  - Those that do not change the geometry of spatial data
  - Those that do change the geometry of spatial data, necessitating changes and updates to (vector) shapes
Multiple Layer Operations

- Multiple layer operations that do not change the geometry of spatial data
  - Select by Location
    - Spatial relationship is specified, spatial features are selected, but spatial data is not geometrically altered
  - Spatial Join
    - Data is appended from a “source” spatial data table to a “destination” spatial data table based on common location, again spatial data is not altered

Select by Location

- Relationships between layers (that you can specify):
  - Intersect
  - within distance of
  - Completely contain
  - Are completely within
  - Have their center in
  - Touch the boundary of
Multiple Layer Operations

- Multiple layer operations that do change the geometry of spatial data (Overlay operations)
  - Used when it is necessary to change the geometry of spatial data to capture the information needed for reporting or analysis
  
  - Spatial data is geometrically modified, requiring new “shapes” to be created and recorded in a GIS database
Multiple Layer Operations

- Multiple layer operations that *do* change the geometry of spatial data
- How are these types of operations accomplished in ArcGIS (ArcMap)
  - ArcToolbox: Contains more complex geometric and spatial analysis tools
Multiple Layer Operations

- Types of geoprocessing operations
  - Dissolve
  - Append (spatial join)
  - Clip
  - Intersect
  - Union
  - Buffer

**Dissolve Operation**

Change in geometry based on common attribute values
Clip Operation

The “Clip feature” is used as a cookie cutter

Buffer Operation

Proximity is measured from target features
Union

- **Union**
  - **Step 1**
    - Ave. rainfall
      - 1 = 5 mm/d
      - 2 = 10 mm/d
      - 3 = 15 mm/d
      - optimum = 2
  - **Step 2**
    - Soil type
      - 10 = clay
      - 20 = sandy loam
      - optimum = 20
  - **Step 3**
    - Optimum growing area:
      - 2 + 20 = 22
Union and Intersect

Union is an AND operation that produces a 3rd output dataset