Feature Types and Data Models

How Does a GIS Work?
- a GIS operates on the premise that all of the features in the real world can be represented by:
  - points (e.g. wells, landmarks, cities on a world map)
  - lines (e.g. roads, rivers, pipelines, transmission lines)
  - polygons (e.g. soils, vegetation types, land-use parcels, counties, states)
  - surfaces (e.g. elevation, temperature, barometric pressure)
- note: how features are represented (as points, lines or polygons) depends upon the scale of the map
- also note that digital airborne or satellite imagery can be added in ArcMap to help visualize features

- these point, line, polygon and surface features are organized into logical layers (e.g. a roads layer, a soils layer)
- and these layers (each representing a particular feature type) can be overlaid to map spatial relationships
- this overlay process is the essence of digital cartography – but a GIS is much more…
  - in a GIS the point, line and polygon layers are associated with an attribute table
  - and each feature represented in a map layer is dynamically linked to a record in the attribute table
  - or, conversely, each record in the attribute table is dynamically linked to a feature on the map

- in other words, a GIS links features in the real world to information about those features
- this relationship between map features and records in an attribute table is extremely important
- it allows us to query and analyze data based upon location (which cannot be done in a standard database)

Demonstration of Texas county data illustrating the identify tool and select tool. Also demonstrated an attribute query.
- an attribute query uses the “Select by Attribute” tool. This type of query be done in any database
  for example: "NAME" = ‘Lubbock’ to locate Lubbock County.
- Last time we also showed a spatial query that uses the “Select by Location” tool to select features in one layer
  based on the location of features in another layer –this feat can only be accomplished in a GIS!
  for example: select all counties from the county layer that are intersected by I-10 in the interstate layer

Feature Types
- In a GIS there are two types of features: discrete features and continuous features

  1) discrete features
    - associated with a specific geographic location
    - points, lines and polygons are all considered to be discrete features
      - points (e.g. cities on a world map, oil wells, landmarks, etc)
      - lines (e.g. streams, roads, pipelines, elevation contours, etc)
      - polygons (e.g. counties, parks, soils, land parcels)

  2) continuous features
    - have no defined location – they can be measured anywhere on a map
    - can be mapped as a surface (e.g. temperature, elevation, precipitation)
    - note that surfaces often start out as a series of sample points (regularly or irregularly spaced)
    - to calculate a surface, GIS interpolates the surface values between the points
Data Models
- to represent features, there are two data models: the vector data model and raster data model
  1) vector data model
    - feature representation:
      - discrete points (x,y coordinate pair)
      - discrete lines (two or more connected x,y coordinate pairs)
      - discrete polygons (three or more x,y coordinate pairs connected to form a polygon)
      - continuous surfaces (must be represented by isolines or polygons)
  2) raster data model
    - feature representation:
      - discrete points (single grid cell with integer cell values to represent feature class codes)
      - discrete lines (connected grid cells with integer values to represent feature class codes)
      - discrete polygons (contiguous group of grid cells with integer values to represent FCCs)
      - continuous surfaces (grid cells are measurement or estimate decimal values)

- advantages and disadvantages of the vector and raster data models
  1) vector data model
    - advantages of the vector model
      - smaller data sets (file sizes)
      - computationally efficient
      - greater precision
      - map features are tied to an attribute table
    - disadvantages of the vector model
      - difficult to handle continuous surfaces
        (surfaces must be represented by isolines or polygons)
  2) raster data model
    - advantages of the raster model
      - ideal for mapping continuous data (elevations, temperatures, etc)
      - ideal for use with digital remote sensing data (digital imagery is a raster data set)
    - disadvantages of the raster model
      - large data sets (file sizes)
      - not computationally efficient
      - less precision
      - features are not tied to an attribute table (see notes below)*

* continuous rasters
  - a continuous raster is used to represent and display surfaces
    - in this case, the grid cell values are decimals that represent a measurement or estimate
      e.g. each grid cell has a unique temperature or elevation value
    - because each grid cell can have a unique decimal value, and there can be millions or grid cells
      in a raster dataset, it is not practical to link each grid cell to a record in an attribute table
      e.g. it is not practical to have an attribute table with millions of records
    - in a continuous raster, there is no attribute table

* discrete rasters
  - a discrete rasters is used to represent points, lines and polygons
    - in this case, the grid cells values are integers that represent feature class codes
      e.g. vegetation class codes, land use class codes, or river class code
    - a discrete raster layer has a value attribute table
    - a value attribute table only shows the number of grid cells associated with each feature class code
## Summary

<table>
<thead>
<tr>
<th>Feature</th>
<th>Type</th>
<th>Vector Data Model</th>
<th>Raster Data Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>points</td>
<td>discrete</td>
<td>x, y coordinate pair</td>
<td>single grid cell (integer feature class codes)</td>
</tr>
<tr>
<td>lines</td>
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<td>two or more connected x, y coord pairs</td>
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<td>polygons</td>
<td>discrete</td>
<td>three or more connected x, y coord pairs</td>
<td>contiguous group of grid cells (integer feature class codes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>that close to form a polygon</td>
<td></td>
</tr>
<tr>
<td>surfaces</td>
<td>continuous</td>
<td>represented by isolines or polygons</td>
<td>usually decimal grid-cell values but can also be integer feature class codes ex. representing land use types</td>
</tr>
</tbody>
</table>

- for general mapping purposes, it is usually best to use …
  - the vector data model to represent discrete points, lines and polygons
  - and the raster data model to represent continuous surfaces.

- **Demonstration** of Kimble County, Texas used to illustrate how points, lines, polygons and surfaces can be represented in a GIS using either the vector or raster data model
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Feature Types and Data Models

How does a GIS work?
- points, lines, polygons and surfaces

Feature Types
- discrete features
- continuous features

Data Models (or Data Structures)
- vector data model
- raster data model
How Does a GIS work?

- a GIS operates on the premise that all of the features in the real world can be represented as either:
  - points
    - wells in a county, cities on a world map
  - lines
    - roads, streams, pipelines, power lines
  - polygons
    - counties in a state, landuse, soil types
  - surfaces
    - elevation, temperature, atmospheric pressure

- note that we can also use imagery to help visualize features
digital airborne or satellite imagery
How does a GIS work?

- these points, lines, polygons, and surfaces are organized into logical layers

- and these layers can be overlaid to map the spatial relationship between features.

- this overlay process is the essence of digital cartography
  - but a GIS is much more than computer mapping…
How does a GIS work?

In a GIS:

- each point, line, or polygon feature is tied to a record in an attribute table (the database)

- and conversely, each record in the attribute table is associated with a particular map feature

features are dynamically linked to attributes
How does a GIS work?

- in other words, a GIS links features in the real world with information about those features.
How does a GIS work?

- this relationship between map features and records in an attribute table is very important ...

- it allows us to query and analyze data based upon location
How does a GIS work?

- whether features are represented as points, lines or polygons depends upon the scale of the map

- on a world map
  - cities are represented as points

- on a county map
  - cities are represented as polygons

- similarly …

- on a U.S. or state map
  - roads are represented as lines

- on a neighborhood map
  - roads are represented as polygons
Types of Features

In a GIS, we recognize two different types of features:

- **discrete** features and **continuous** features

1) Discrete Features

- associated with a specific geographic location

- points, lines and polygons are all considered discrete features

  - **points**
    - cities (on a world map), oil wells, landmarks

  - **lines**
    - streams, roads, pipelines, elevation contours

  - **polygons**
    - counties, parks, soils, land parcels
Types of Features

In a GIS, we recognize two different types of features:

- discrete features and continuous features

2) Continuous Features

- can be measured anywhere on a map

- continuous features can be mapped as a surface
  - elevation, temperature, precipitation

* note that surfaces often start out as a series of sample points
  - sample points may be regularly or irregularly spaced
  - to calculate a surface, GIS interpolates values between the sample points
Types of Features

Discrete Features – points, lines and polygons

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Types of Features

**Continuous Feature** – no discrete location – values are found everywhere

Temperature surface created from direct satellite measurements.
To represent these discrete and continuous features, there are two data models:

1) Vector Data Model
   - uses x, y coordinates to represent features

2) Raster Data Model
   - uses grid cells to represent features
1) Vector Data Model

- feature representation:

  - discrete points
    - \((x, y)\) coordinate pair

  - discrete lines
    - two or more connected \((x, y)\) coordinate pairs

  - discrete polygons
    - three or more connected \((x, y)\) coordinate pairs that close to form a polygon

  - continuous surfaces
    - must be represented by isolines or polygons
2) Raster Data Model

- feature representation:
  
  - discrete points
    single grid cell – integer cell value (FCC feature class code)
  
  - discrete lines
    connected grid cells – integer cell values (FCC)
  
  - discrete polygons
    contiguous group of grid cells – integer cell values (FCC)
  
  - continuous surfaces
    all cells are usually represented by decimal values
Data Models (Vector and Raster)

Discrete Points

- vector

x, y

x axis = longitude

y axis = latitude

- raster

Cell values

= 1

= NoData

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Data Models (Vector and Raster)

Discrete Lines

- vector

- raster

Cell values

- = 1
- = NoData

x, y

y axis = latitude

x axis = longitude
Data Models (Vector and Raster)

Discrete Polygons

- vector

- raster

x, y

y axis = latitude

x axis = longitude

Cell values

= 1

= NoData

x, y

x, y

x, y

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Data Models (Vector and Raster)

Continuous Surfaces

vector (isolines)

x axis = longitude

y axis = latitude

raster

Cell values

- = 52.4 degrees F
- = 82.6 degrees F

Temperature
Data Models (Vector and Raster)

Vector Data Model

- advantages of the vector model
  - smaller data sets (file sizes)
  - computationally efficient
  - greater precision
  - map features are tied to an attribute table

- disadvantages of the vector model
  - continuous surfaces can be difficult to handle
    (surfaces must be represented by isolines or polygons)
Data Models (Vector and Raster)

Raster Data Model

- advantages of the raster model
  - ideal for mapping continuous data (elevations, temperatures)
  - ideal for use with digital remote sensing data (imagery is a raster)
    (e.g. we can classify imagery into land use types – raster land use)

- disadvantages of the raster model
  - large data sets (file sizes)
  - not computationally efficient
  - less precision
  - features not tied to an attribute table*

* Two types of raster surfaces
  - continuous rasters (surfaces)
    - grid cells are composed of decimal values (each cell can be unique)
    - grid cells are not tied to an attribute table (too many unique values)

  - discrete rasters (points, lines and polygons)
    - grid cell are composed of integer values (feature class code ex. land use value)
    - layer has only a **value attribute table** (with number of cells in each class)
## Data Models (Vector and Raster)

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Data Models (Vector and Raster)

Which data model is best?

For general mapping purposes, it is usually best to use:

- **vector**
  - points
  - lines
  - polygons

- **raster**
  - continuous surfaces
Housekeeping

Navigate to Gis.ttu.edu/gist3300

Syllabus updated for GIST3300 – check out new schedule

Homework for lecture

Gis.ttu.edu/gist3300

Check out the links:
- Esri products and ArcGIS for Desktop
- View the video: Geospatial Revolution Episode 1