The many ways of GIS for digital humanities

Summer School on Digital Humanities
Course material available at
https://github.com/AugustoCiuffoletti/DHSS_2025

Augusto Ciuffoletti

24 marzo 2025

What is digital cartography (aka GIS)

- Digital cartography shares fundamental principles with classical cartography:
  - It records the geographical position of objects or reference points.
  - It represents the morphological features of the landscape.
  - It maps travel routes and pathways.
  - It associates specific attributes and characteristics with mapped objects.
  - It can depict imaginary landscapes or reconstruct past and future territorial scenarios.

Why do we use digital cartography?

- Digital and conventional cartography share similar purposes.
- Both serve as essential tools for:
  - Measuring geometric dimensions of objects and areas.
  - Defining and recording state and property boundaries.
  - Planning and navigating routes to specific destinations.
  - Documenting journeys and various forms of travel.
  - Geographically situating human or natural events to analyze relationships.
  - Depicting and teaching about distant or inaccessible places.
- These applications can relate to the present, as well as to past or future scenarios.

The advantages of digital cartography

- Digital and traditional cartography differ primarily in the medium! used to store maps.
  - Digital maps are recorded on various types of digital media and accessed via suitable devices.
- This distinction brings several key advantages:
  - Easy sharing due to the dematerialization of maps.
  - Automatic acquisition of positions and movements.
  - Ability to merge data from multiple maps.
  - Integration of multimedia information.
  - Simplified creation and reuse of maps.

Cartography and public history

- History and cartography are deeply interconnected.
  - History records events in relation to places.
- The way we represent the world reflects our perspectives and values.
- Was a medieval geographer creating maps for his king a public historian?
  - Engaging the public with the past.
  - Applying history to practical use.
  - Encouraging critical reflection.
- Can the T-and-O map be considered a public history document?
- Will today's maps become public history documents in the future?
- Who has the authority to create such historical records?
- Digital cartography introduces new perspectives on this question.
  - The answer depends on its accessibility and widespread use.

Diffusion of digital cartography

- Digital cartography relies on:
  - Powerful graphics processors
  - High-definition displays
- In the Pentium era, these were largely inaccessible to personal computers
  - ...limiting the advantages previously mentioned
- Digital cartography became widely affordable around 2005
- Today, nearly everyone carries a pocket-sized GIS engine
- Despite advancements, multiple representation standards still exist (standardization is ongoing)
- Cartography is now accessible to anyone with the necessary technical skills
- Current challenges:
  - Simplifying access to cartographic tools
  - Harmonizing representation to enable data integration
- Future directions:
  - Developing autonomous devices to continuously record environmental features
  - Enhancing the communication of historical narratives

Web Mapping

- The Web is a powerful medium for sharing resources
- Web mapping technology emerged a few years after the creation of the WWW in 1989
- The evolution of the Web paralleled the advancement of Web mapping
- In the early '90s, maps were primarily static, offering limited interaction or layering
- By the late '90s, users gained the ability to manipulate maps and create new ones
  - ...with computationally intensive tasks handled on the server side
- Between 2000 and 2005, advancements in Web technologies facilitated the rise of Web mapping services
  - ...enabling seamless integration with other services via standardized interfaces
  - ...making the definition of standard representations and protocols increasingly important

Web Mapping in Web 2.0

- More powerful personal computing devices enable real-time interaction with Web mapping servers
  - ...allowing maps to be generated as mashups from multiple databases
- The advent of Web 2.0 (2005) introduces crowd-sourced geospatial data
- Increased computing power enables client-side manipulation of map features
  - ...with cloud storage and servers facilitating authentication and data sharing

Access: open vs closed digital cartography

- A fundamental choice in online content:
  - Data can be publicly accessible or restricted to private use
- The same distinction applies to digital cartography

Examples:

- **Open-source cartography:** OpenStreetMap
  - Maps are freely available in the public domain
  - Anyone can contribute by adding features
  - Maps can be reused without restrictions
- **Freely accessible but proprietary cartography:** Google Maps
  - Access is provided through a private service
  - Users can create and overlay their own maps
- **Commercial/private cartography:** Mapbox
  - Maps are provided as a paid service
  - Costs scale with usage (e.g., number of views)

The many ways of GIS for digital humanities

Fundamental Core Concepts

- Concepts that **simplify access** to geographic data
- **Coordinates**: Latitude and Longitude
- **Geographic Features**:
  - Point – Defined by a single coordinate pair
  - Segment – A straight line connecting two points
  - Line – A sequence of connected segments
  - Area – A closed shape formed by a continuous line
- **Data Models**:
  - Vector Model – A collection of features with attributes
  - Raster Model – A grid of cells storing attributes
    - Often derived from graphic formats like JPEG
- **Additional Core Elements**:
  - Attributes – Data linked to features and cells
  - Layers – Organized sets of maps for structured visualization
- A suite of tools supports the manipulation and visualization of these concepts
- Those that **simplify access**

Geographic Coordinate Systems

- A Geographic Coordinate System (GCS) defines how a point is represented on the Earth's surface
- A standard GCS plays a crucial role in sharing meaningful information about positions, paths, and distances
- The standard evolves over time to accommodate changing needs and advances in technology
  - Originally, latitude was computed based on the maximum duration of daylight

World Geodetic System of 1984

- A widely adopted Geographic Coordinate System (GCS) today is `WGS84` (World Geodetic System 1984)
- The label `EPSG4326` refers to its "non-projected" version
  - For example, `EPSG:3856` represents its Pseudo-Mercator projection on a square surface
- `WGS84 EPSG4326` is used by the Global Positioning System (GPS) and for data storage formats such as GeoJSON
- `WGS84 EPSG3856` is used by Google Maps and computer visualization tools
- Key features of `WGS84 EPSG4326`:
  - Coordinates are expressed in latitude (north) and longitude (east) (in this order)
  - Coordinates are expressed in degrees (decimal format)

Goals

- This tutorial provides the **fundamental** skills required to update and create GIS maps
- We approach GIS from different perspectives (local, server-based, and cloud)
- The tutorial covers the basics of:
  - Creating new features
  - Generating new raster layers
  - Tracking an itinerary using a GPS receiver
  - Uploading our track to a GIS map
  - Creating a new GIS service

A glimpse on GIS databases

- Specialized databases store features and their associated attributes
- Example in PostGIS:

```
INSERT INTO places (name, coord)
    VALUES ('Pisa', ST_GeographyFromText ('SRID␣=␣4326;␣POINT␣(10.41␣43.72)'));
```

- Legend:
  - places is a table I created earlier
  - It contains two columns: one for the name of a point and one for its coordinates
  - Using the INSERT command, I can add a new entry
  - The new point is named *Pisa*
  - Coordinates are added using the STGeographyFromText function in PostGIS
  - The text string includes an SRID parameter to specify the Coordinate system
  - `4326` refers to `WGS84 EPSG:4326`
  - The coordinates follow a specific format: first longitude, then latitude (note the reversal from `WGS84` convention)
- Specialized databases register features and attributes

GeoJSON is gaining momentum

- GeoJSON is an extension of the JSON object description language
- It is flexible and programmer-friendly
- It is commonly hosted by NoSQL databases
- Example in GeoJSON:

```
{ "type": "Feature",
  "properties": {},
  "geometry": {
    "type": "Point",
    "coordinates": [ 12.338194, 45.433048 ]
  }
}
```