

The many ways of GIS for digital humanities

Summer School on Digital Humanities

Course material available at

https://github.com/AugustoCiuffoletti/DHSS_2025

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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 capability to create such historical records?
 - Digital cartography opens new perspectives on this sense
 - The answer depends on 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 PCs
 - ...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 technically accessible to anyone
- 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)

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 EPSG:4326 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 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
- An example in Postgis:

GeoJSON is gaining momentum

- GeoJSON is a GIS 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 ]  
  }  
}
```

Going deeper

The rest of this tutorial is divided into six introductory hands-on sessions:

- Fundamentals of QGIS
- Working with OpenStreetMap
- Creating Maps with uMap
- Using GaiaGPS for Field Data
- Georeferencing in QGIS
- Introduction to the Leaflet Library