8 Mapping and GIS

This chapter focuses on GIS or Geographic Information Systems. These systems are designed to integrate maps with data for analysis and presentation. Most GIS systems were not developed for the humanities, but to map natural and social phenomena. As you work through the exercises and materials, keep in mind the challenges of using these systems to address humanistic issues and research.

8a GIS in the humanities

Exercise 8.1: Comparing historical records

Compare the maps of emancipation in the American Civil War with patterns of lynching in the United States. How do the maps assist in analysis?

- https://dsl.richmond.edu/emancipation/
- https://lynchinginamerica.eji.org/

How-to example

Comparing the Emancipation Proclamation maps with the lynching maps reveals significant insights into the sociopolitical landscape of American history. The emancipation maps illustrate the regions where enslaved people were declared free during the Civil War, while the lynching maps show the areas where racial violence was prevalent from 1877 to 1950. By examining these maps together, one can identify geographical overlaps, suggesting patterns of resistance to African American freedom and progress. This comparison highlights the historical continuity of racial oppression, showing how the promise of emancipation was met with severe backlash and violence. These maps also offer a visual representation of the sociopolitical climate of the periods, illustrating regions with strong Confederate sympathies and resistance to Reconstruction efforts. Additionally, they underscore the impact of lynching on African American communities, revealing where they faced the most terror and oppression. Overall, these maps serve as powerful educational tools, helping to visualize the complexities of American history, the aftermath of slavery, and the persistent legacy of racism.

Exercise 8.2: Gallery of projects

Review the critical assessment criteria for GIS projects:

- What information is in the base map? Is it focused on roads, rivers, and other transportation routes? Or on geological and physical features? Does it map administrative boundaries? Or show cultural aspects of an area? Is it anachronistic in relation to the data? Does it show features of the landscape that would not have been present at the time of the events?
- What layers exist in the mapping platform and how do they support the base map? Can you toggle the layers easily? What data belongs on which layer?
- What kinds of data are being mapped? Are they mainly coordinate points? Or do they have a spatial dimension in which the location is a dynamic aspect of the events shown? Was the data quantitative or qualitative and how were these given graphical expression?
- Can you see the data and its structure? What elements were codified in the data? Was it created in a markup language, in GeoJSON, or a spreadsheet, and what custom fields were defined by the researchers?
- Does the map serve as a picture of a location or as an informative element of the research? If the map is a historical map, have its features been connected to a contemporary coordinate system?
- How are elements of spatial experience communicated in the project—through narration, visualization, or primary documents?

- If pop-up windows are used to display comments and/or documents (images, correspondence, newspapers, etc.), do they block the view of the map? How effective is the connection between the depiction of space or geography and the display?

Look through some of the projects in the list below and see how they meet the critical assessment criteria outlined above. Which are still working, which are not, and how effectively do they integrate research issues, data, maps, and arguments?

- DH GIS projects (https://anterotesis.com/wordpress/mapping-resources/dh-gis-projects/)
- Orbis (http://orbis.stanford.edu/)
- Gulag Online (http://www.gulag.online/places?locale=en)
- Historypin.org (http://www.historypin.org/en/)
- Artists in Paris (http://www.artistsinparis.org/)
- Atlantic Networks Projects (https://sites.google.com/site/atlanticnetworksproject/)
- Legacies of British Slave-ownership (http://www.ucl.ac.uk/lbs/maps/)
- HGIS de las Indias (http://www.hgis-indias.net/cmv-app-master/viewer/)
- Yellow Star Houses in Budapest (http://www.yellowstarhouses.org/)

How-to example

The Gulag Online (http://www.gulag.online/places?locale=en) project is an impressive digital resource that accurately maps the locations and infrastructure of the Soviet-era Gulag camp system, using a combination of geographical features, satellite images, and detailed military maps. The project incorporates multiple layers, such as camp locations, administrative boundaries, and documented stories, providing a comprehensive view of the camps and their historical context. Users can easily toggle between layers, and the data is presented in a clear and concise manner. The map is still functional, with no reported errors or missing plugins, and the data structure uses GeoJSON and other formats, integrating both quantitative and qualitative aspects. The project's main purpose is to serve as an informative element of research, visualizing the spatial experience of the Gulag system through visualization and primary documents. The pop-up windows displaying additional information, such as testimonies and historical context, effectively enhance the connection between the depiction of space and the display of information, making the Gulag Online project a valuable tool for understanding Soviet repression.

Exercise 8.3: Spatial scholarship

Complete one of the mapping tutorials listed here: https://spatial.scholarslab.org/stepbystep/.

How-to example

For more resources along these lines, look at this libguide (https://libguides.library.arizona.edu/dighumantools/maps) by Anthony Sanchez on Digital Humanities Tools for mapping.

Exercise 8.4: Cartographic projections

Look at this gallery of projections (http://www.icsm.gov.au/education/fundamentals-mapping/projections/commonly-used-map-projections) and familiarize yourself with their distortions. Can you describe some of the goals that different projections are attempting to meet?

How-to example

Different map projections aim to balance various distortions that arise when translating the Earth's three-dimensional surface onto a two-dimensional map. Projections like the Gall-Peters maintain area accuracy, ensuring correct proportions of landmasses, while conformal projections, such as the Mercator, preserve shapes, making them ideal for navigation. Equidistant projections maintain accurate distances from the center to other points, useful for radio mapping, whereas azimuthal projections preserve direction, aiding air navigation. Projections that attempt to compromise, like the Robinson, strive to minimize overall distortion by balancing area, shape, distance, and direction, creating visually appealing world maps. Each type of projection serves different needs, with strengths tailored to specific applications.

Exercise 8.5: Strange maps

Look at these "strange" maps (http://bigthink.com/blogs/strange-maps) maps for inspiration. Pick one and describe its features. What does the map show and how does it operate?

How-to example

One intriguing map from the "Strange Maps" collection is "The Big Map of Who Lived When" (https://bigthink.com/strange-maps/the-big-map-of-who-lived-when/). This map plots the lifespans of historical figures, ranging from contemporary personalities like Eminem to ancient figures like Genghis Khan. The map operates by visually representing the lifespans of these individuals on a timeline, allowing users to see overlaps and gaps between different historical periods. It also classifies these different historical figures by different societal roles using color. It provides a unique perspective on history by highlighting the temporal relationships between various figures, making it easier to understand the chronological context of their lives and contributions.

Exercise 8.6: Mapping Indigenous knowledge

Compare these two projects for their approach to mapping Indigenous knowledge and experience:

- Maps are Territories (http://territories.indigenousknowledge.org/)
- Perspectives on A Selection of Gabrieleño/Tongva Places from UCLA Mapping Indigenous LA (https://mila.ss.ucla.edu/)

How-to example

Both projects aim to map Indigenous knowledge and experience, but they approach it in distinct ways:

Maps are Territories focuses on analyzing maps as both a metaphor for knowledge and a means of knowledge representation across various cultures. The project emphasizes the cultural dimensions of human perception of the natural environment, aiming to highlight how different cultures construct and understand nature. It is structured as a series of museum or gallery exhibits designed to exercise visualization and visual analysis skills.

Perspectives on A Selection of Gabrieleño/Tongva Places is a decolonial mapping project that centers Indigenous knowledge and voices. It uses the StoryMaps platform to recenter Indigenous toponymies and narratives, including video interviews. The project aims to honor historic ceremonies, cultural practices, and landscapes, providing a digital network for communities to share their stories and learn from each other.

While Maps are Territories takes a broader, cross-cultural approach to understanding maps as knowledge representations, Perspectives on A Selection of Gabrieleño/Tongva Places focuses specifically on decolonizing cartography and recentering Indigenous perspectives in Southern California.

Recommended readings

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8b Practical approaches to GIS

Bonus content: evolution of drones and remote sensing

Since the Wright brothers invented the plane, there have been attempts to make an autonomous or remotely piloted aircraft (Colomina and Molina 2014). The era of remote sensing began with the launch of the first Earth observation satellites in the mid-20th century, such as the US Landsat program in 1972 (Library of Congress). These early satellites provided invaluable data for mapping, environmental monitoring, and resource management, but they were expensive, required specialized infrastructure, and offered limited resolution compared to modern standards. The development of drone technology marked a significant shift in remote sensing capabilities. Drones like the MQ-1 Predator in the 1990s demonstrated the potential of unmanned aerial systems for detailed and flexible surveillance. Over time, advances in miniaturization, battery efficiency, and sensor technology facilitated the transition of drones from exclusively military use to civilian and scientific applications. Key milestones include the development of affordable, lightweight consumer drones in the early 2000s and the integration of sophisticated cameras, LiDAR (Light Detection and Ranging) systems, and thermal sensors. These innovations expanded the versatility of drones, enabling their use in agriculture, disaster response, archaeology, and urban planning.

Today, drones represent a new frontier in remote sensing, offering unprecedented accessibility and precision. Unlike satellites, which are limited by orbital paths and resolution constraints, drones provide on-demand, high-resolution data collection tailored to specific research or operational needs. This transition from large-scale satellite systems to agile, local drone platforms exemplifies the democratization of remote sensing technologies, empowering researchers and practitioners across disciplines to gather and analyze spatial data with remarkable efficiency.

Bonus content: drone types

Drones, also known as unmanned aerial vehicles (UAVs), play a pivotal role in modern data collection. Equipped with high-resolution cameras and remote sensing instruments, drones offer both precision and flexibility, allowing researchers to access areas that may be too remote, hazardous, or otherwise inaccessible. Their cost-effectiveness and growing accessibility have popularized their use as a data collection method for a broader range of disciplines and users.

UAVs come in various forms tailored to specific applications and operational needs (Zhang and Zhu 2023). Fixed-wing drones are reminiscent of traditional airplanes. They have large wings to provide lift with either front propellers or jet engines for propulsion. This design makes them easy to fly straight, but more of a challenge to steer, hover, or maneuver in tight spaces. Their plane-like structure increases energy-efficiency, flight times, and range. However, fixed-wing drones typically require a runway or catapult for takeoff and landing, which adds to their operational complexity and cost. In contrast, rotary-wing drones—such as quadcopters, hexacopters, and octocopters—use multiple rotors for lift and propulsion, like a helicopter. Typically, they are more easily portable, and the design allows them to perform vertical takeoff and landing. They are ideal for tasks requiring hovering or precise maneuvering, such as close-range inspections of tall ruins, photography of large architecture, and real-time monitoring of culturally significant areas or structures. These UAVs are also more accessible to operate; however, they consume more battery power, resulting in shorter flight times and limited range, which makes them less suitable for covering large areas compared to fixed-wing drones.

Drones are also often categorized as either commercial or industrial-grade. As one might expect, commercial drones, such as DJI's Phantom and Mavic series, are characterized by their affordability, portability, and ease of operation. These drones are ideal for aerial photography and videography, photogrammetry, and small-scale mapping. In contrast, industrial-grade drones are equipped with advanced sensors and higher payload capacities for professional tasks such as infrastructure inspection, precision mapping, and disaster response. These models often include features such as collision avoidance and extended flight capabilities, making them reliable for high-stakes operations. Although they are more expensive and complex to operate, industrial-grade drones, like the DJI Matrice and senseFly eBee series, provide the robustness and specialized functionality required for demanding environments.

Bonus content: sensors and payloads

Many drones are equipped with the functionality to carry and deploy various sensors and payloads, which determine the range and depth of data they can collect (Zhang and Zhu 2023). Among the most common are cameras. The type of camera will be tailored to different applications. RGB cameras, which capture high-resolution color images, are widely used in aerial photography and videography because they are ideal for visual inspections and mapping. Thermal cameras, which use infrared radiation to detect heat signatures, are indispensable for search-and-rescue operations, building inspections, and wildlife monitoring. For more detailed material analysis, multispectral and hyperspectral cameras, which are designed to capture how light interacts with objects, provide imagery across multiple bands of the electromagnetic spectrum, enabling identification of materials and compounds, increasing insights into vegetation health, water quality, and material composition.

Outside of cameras, drones can be equipped with LiDAR systems, which use a laser to illuminate a spot on a target and a sensor to measure how long it takes the reflected light to bounce back. These highly precise measurements can create detailed 3D renderings of objects, buildings, and landscapes. (LiDAR will be discussed in more detail in later chapters.) Drones can also be outfitted with other types of sensors, such as gas sensors to monitor air quality or detect hazardous chemicals, radar sensors to enhance navigation and obstacle detection in low-visibility conditions, and acoustic sensors to monitor wildlife or detect sound anomalies. The ability to adapt drones with specialized payloads to meet the needs of varying jobs makes them valuable tools for data collection.

Bonus content: humanistic drone applications

There are a growing number of applications for remote sensing with drones—industrial inspections, damage surveys, event planning, agriculture, construction, and ecological conservation—just to name a few. In terms of humanistic research, UAVs are frequently being used for site mapping and artifact preservation in archaeology and cultural heritage. LiDAR-equipped drones enable rapid exploration of overgrown, hidden, or partially buried sites without disturbing the ground. Organizations like CyArk (https://www.cyark.org/), a nonprofit dedicated to digitally preserving cultural heritage, use this technology to document and safeguard historical landmarks. By conducting non-invasive surveys, these drones preserve the landscape while capturing precise 3D models, ensuring that even fragile or inaccessible sites can be studied and protected without risking interference with underlying structures or artifacts. The growth of environmental humanities has been supported by done and remote sensing technologies, which allow for better integration of spatial and ecological data into cultural, historical, and ethical inquiries, fostering interdisciplinary approaches to environmental challenges so we can more deeply explore the complex relationships between humans and the environment. In addition, arts practitioners are considering UAVs and data collected from remote sensing technologies as tools for artistic expression. For example, Elisa Serafinelli and Lauren Alex O'Hagan lead the "Drones in Visual Culture" funded by the Arts and Humanities Research Council, the impact of drones on how we visualize the world (Jackman 2021).

Bonus content: drone workflows

Drone methods and workflows involve a series of carefully planned and executed steps to ensure accurate and meaningful data collection. But before any flying can begin, operators need to obtain the required licenses and certifications to legally pilot the drones. While the requirements vary depending on the location, responsible pilots must be aware of local and federal aviation and safety regulations regarding where and how drones can be flown, altitude restrictions, and prohibited zones. Certain drones require registration and insurance, and operators need to regularly renew their certifications and licenses to ensure they are up-to-date on the latest emergency procedures and airspace regulations. The process can then begin with flight planning and mission design, where operators define the area of interest, flight paths, altitude, and sensor settings, often using specialized software to optimize coverage and resolution. During the data acquisition phase, drones are deployed to capture imagery, LiDAR scans, or other sensor outputs, following the predetermined flight plan. Depending on equipment, data may need to be offloaded frequently in the field due to limited storage or equipment may require a WiFi and/or internet connection to upload to the cloud or another device. Processing the data will depend on the type of data which was collected. For example, image data is usually raw image (.tiff) or video (.mp4,.lrf,.srt) files that will require stitching to combine multiple images into a seamless mosaic. Other common drone data types include 3D point cloud (.xyz, .las), 3D textured mesh (.obj, .fbx, .dxf, .ply), orthomosaics (.geotiff, .tiff, .kml), and digital elevation models (.dem, .geotiff, .tiff, .kml). Usually, all drone data will require georeferencing to align the data with real-world coordinates (longitude, latitude, and relative altitude) for spatial accuracy, so that the models can be properly scaled and oriented. The data also contains date and time stamps and can vary in size, depending on the capture settings. Sharing the output of drone data (3D model or detailed maps) may require a viewer—such as Potree, QGIS, or ArcGIS—which can support the rendering of big data in real time.

Bonus content: challenges, limitations, and ethical considerations

Despite the many advantages of drone-use, there are technical, regulatory, and data-related challenges that hinder their effectiveness. Considering the technical specifications, drones—particularly rotary-wing drones—are limited by short battery life, which restricts flight duration and constrains the types and amounts of sensors or equipment they can carry. Like many highly technical markets, drone and remote sensing technologies are progressing rapidly, making it expensive and time-consuming to keep up with the latest advancements. Furthermore, the volume, quality, and standardization of data collected by drones vary widely. Additionally, drones can only be operated successfully under certain weather conditions; strong winds, rain, or extreme temperatures compromise performance or can prevent flight altogether. Airspace restrictions, particularly near urban centers, airports, or sensitive locations, can limit where drones can be deployed.

As technology historically tied to the military industrial complex, there are also important ethical and social considerations related to drone and remote sensing. Equipped with high-resolution cameras or sensors, UAVs can inadvertently or intentionally capture sensitive information. What is the consequence? In what ways does drone surveillance differ from other forms of surveillance? Do people have a right to a certain level of privacy? Where does consent fit in when it comes to airspace? Additionally, what impact does drones use have on the planet? From energy consumption to electronic and mechanical waste from discarded or broken components, are their sustainable and ecological practices to mitigate harm?

Ethical frameworks and community engagement are critical to addressing these concerns, ensuring that drones are used responsibly and inclusively to serve societal needs without exacerbating inequities or environmental degradation.

Moreover, what does equitable access to drone technology look like? What steps can be taken to prevent widening gaps between resource-rich and resource-poor communities, particularly in applications like disaster response or environmental monitoring? Currently, the advancements in AI and machine learning have begun to be integrated both into how drones operate, as well as into their post-production processes. With the increase in drone autonomy (e.g., pre-programmed flight paths, self-piloting, automatic recharging) and the development of increasingly "smarter" sensors, these broader implications for industry, society, and research will become essential to an ethical methodology for drone use. **[See Bonus Exercise: Artists' projects using drones]**

Exercise 8.7: comparing QGIS and Leaflet

Start by looking at the documentation of Leaflet (https://leafletjs.com/) and QGIS (https://www.qgis.org/). What difference in approaches do you notice?

How-to example

The contrast between them is educational. QGIS (https://www.qgis.org/) begins with data. Its features are designed with attention to the analytic functionality of its platform, leading with data types and formats specific to geospatial information work. Leaflet focuses on the graphical components and research behaviors they support: maps, layers, controls, and graphical features and utilities. Leaflet (https://leafletjs.com/) assumes you want to make a map and show things on it. Either can be used to show information that is specific to geographical data.

Exercise 8.8: StoryMaps

Embedding maps in a historical narrative can be compelling. Look through this project gallery of StoryMaps (https://collections.storymaps.esri.com/humanities/) and consider the advantages and some of the challenges or liabilities in such projects?

How-to example

Incorporating maps into historical narratives provides visual context that aids comprehension, aids in simplifying complex information, and captures audience interest with interactive features. Maps can vividly depict temporal changes, highlight spatial relationships, and bring historical events to life. However, maps can run the risk of oversimplifying details. To make maps with integrity, you need accurate and trustworthy data. Technically, digital maps need to follow accessibility standards. In terms of preservation and access, creators should also consider interoperability and device compatibility when choosing a mapping platform or application. Balancing these aspects is key to creating effective and engaging historical narratives with embedded maps.

Bonus exercise: humanistic drone-mapping

Consider one of the examples of humanistic drone-mapping applications below. Using specific examples from the videos, write a short analysis exploring the intersection of drone technology, social justice, and the Digital Humanities. Highlight the opportunities and challenges presented by these applications and suggest ways in which they can further support equity and resilience in affected communities.

- Dayaks and Drones—Using GPS Drone Technology Community Mapping—Indonesia (https://www.youtube.com/watch?v=p5Q1qWut9d0)
- DRONEBIRD: Disaster Crisis Response (https://usc.zoom.us/rec/play/ag8AJ8MmLJISG60hVxtEQXm591yuCT15b3-Un3Za7w2dB_6Mc3eVgIXnM_IsGfCuM-r5s98zPo1v4l97.nPada1F5_WeC3s1X?canPlayFromShare=true&from=share_recording_detail&continueMode=true&componentName=rec-play&originRequestUrl=https%3A%2F%2Fusc.zoom.us%2Frec%2Fshare%2FzAd4P1lEGOzcAmTBfwFm1YMcP-5HhuH5nJm4GP1AREtRUV0d2f_pZpyegr6dnw2D.4JJxqed-I0qnbIR7)

How-to example

The Dayaks and Drones project (https://www.youtube.com/watch?v=p5Q1qWut9d0) in Indonesia exemplifies how drone technology can empower Indigenous communities by enabling the Dayak people to map their own territories using GPS. This initiative supports their legal recognition and autonomy by protecting their lands against illegal logging and encroachment. It also aids in preserving their cultural heritage by documenting vital cultural sites and resources, while contributing to environmental conservation by providing accurate maps for monitoring landscape changes. However, challenges such as accessibility to technology, the need for technical training, and the careful management of sensitive data must be addressed to ensure the project's sustainability and effectiveness.

Bonus exercise: artists' projects using drones

Artists use drones to create artworks in various ways such as aerial photography, mapping, painting with light, and in swarms in real time. Look at these:

- An international view of women artists using drones: Drones in the World of Art (https://www.womenwhodrone.co/single-post/drones-in-the-world-of-art)
- Kami Shah, "Drone Art: How it is Redefining Creative Expression," April 4, 2024: https://dronstechnology.com/drone-art-how-it-is-redefining-creative-expression/
- Michelle, "Elevating Creativity: Drone Art and Creative Projects." September 16, 2023: https://dronesandyou.com/drone-art/

What kind of art project can you imagine designing using drones? What challenges are there for preservation of these projects?

How-to example

Preserving drone-based art projects presents several unique challenges. First, the ephemeral nature of drone art, especially performances like light shows or real-time swarms, makes capturing the essence of these works through high-quality video, photography, or even virtual reality essential. However, replicating the live, immersive experience is difficult. Second, the rapid pace of technological advancement means that the drones and software used today may become obsolete in the future, necessitating the maintenance or updating of these technologies for long-term preservation. Additionally, outdoor installations are subject to weather conditions, impacting drone performance and safety, adding unpredictability to consistent preservation efforts. Navigating the legal landscape for drone use, particularly in public spaces or urban environments, is another complexity that may affect the future ability to perform or recreate these artworks. Lastly, preserving data generated by drones, such as flight paths, imagery, and choreography, requires robust storage solutions, ensuring the security and integrity of this data over time to maintain the authenticity of the artwork. Addressing these challenges through careful planning, documentation, and collaboration with technological, legal, and informational experts can help artists work toward preserving the innovative and dynamic nature of drone art for future generations.

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Resources

- Anterotesis (https://anterotesis.com/wordpress/mapping-resources/dh-gis-projects/)
- Converter KML-GeoJson (https://mygeodata.cloud/converter/kml-to-geojson)
- David Rumsey's Map Collection contains 10,000 digitized historical items (http://www.davidrumsey.com/)
- Fabricius, Tashia et al., XR (Extended Reality) with ArcGIS (https://www.youtube.com/watch?v=OFnwHDouS7I)
- Geocoding Tutorial (http://mapninja.github.io/Tutorial-Geocoding-Crash-Course/)
- Geocoding API Overview (https://developers.google.com/maps/documentation/geocoding/overview)
- History of Remote Sensing (Library of Congress) (https://guides.loc.gov/geospatial/computer-cartography-archive/history-of-remote-sensing)
- Leaflet (https://leafletjs.com/reference-1.6.0.html)
- Mullen, Lincoln, on Georectification (https://lincolnmullen.com/projects/spatial-workshop/georectification.html)
- Mullen, Lincoln, Spatial Humanities Workshop (https://lincolnmullen.com/projects/spatial-workshop)
- Neatline (https://neatline.org/showcase/)
- Programming historian (https://programminghistorian.org/en/lessons/?topic=mapping)
- Programming historian QGIS (https://programminghistorian.org/en/lessons/qgis-layers)
- Projections (http://www.icsm.gov.au/education/fundamentals-mapping/projections/commonly-used-map-projections)
- QGIS Documentation (https://docs.qgis.org/3.40/en/docs/index.html)
- QGIS Features (https://docs.qgis.org/3.10/en/docs/user_manual/preamble/features.html)
- QGIS Tutorials (http://www.qgistutorials.com/en/)
- Raster and Vector (https://gisgeography.com/spatial-data-types-vector-raster/)
- What are Raster and Vector data in GIS and when to use? (https://gis.stackexchange.com/questions/7077/what-are-raster-and-vector-data-in-gis-and-when-to-use)
- University of Arizona, LibGuide (Anthony Sanchez) (https://libguides.library.arizona.edu/dighumantools/maps)
- University of Sheffield, Drones in Visual Culture (https://gtr.ukri.org/projects?ref=AH%2FT012528%2F1)