Introduction
Geospatial Analytics

Transforming a (potentially large) set of isolated facts about *when* and *where* objects/people/phenomena were or moved into higher-level knowledge:

- Summarizing complex events and phenomena
- Providing insights about the general structure (global view)
- Identifying specific interesting patterns (local view)
- Enable predictions or educated guesses
Historical Examples
The Odyssey is the story of...a trajectory

“A man who has been through bitter experiences and travelled far enjoys even his sufferings after a time”

Homer, Odyssey
The Odyssey is the story of...a trajectory

“ma misi me per l’alto mare aperto
sol con un legno e con quella compagna picciola da la qual non fui diserto.
L’un lito e l’altro vidi infin la Spagna,
fin nel Morrocco, e l’isola d’i Sardi,
e l’altre che quel mare intorno bagna.”

Dante’s Inferno, Canto XXVI
French army in the Russian campaign (1812-1813)
Charles Minard, 1869
Number of passengers between Dijon and Mulhouse
Charles Minard, 1845
The Spread of the Black Death (1346–1353)
John Snow and the Broad Street cholera outbreak (1854)
John Snow and the Broad Street cholera outbreak (1854)
Predicting criminals’ trajectory

1930s

Bonny & Clyde
Predicting criminals’ trajectory
1930s

The Bonny & Clyde task force
CLYDE AND BONNIE RIDDLED WITH MACHINE GUN BULLETS
Tracking the movements of dissidents
1970s-1980s

- Stasi sprayed a radioactive solution on the floors of the rooms where suspected dissidents met.
- The solution adhered to dissidents’ shoes, allowing agents to track who attended a meeting there.
- Agents wore portable Geiger counters that activate when a suspected dissident was nearby.
Birth and death place of notable individuals

- (C) Birth-death locations scatter plot, cumulated over all time with outliers colored as birth sources (blue) and death attractors (red)
- (D) Illustration of birth-death flows of antiquarians in the 18th century
- (E) Migration in Europe, with node size corresponding to PageRank
The Big Data era
Digital Footprints of Human Activity

Shopping patterns
Digital Footprints of Human Activity

Shopping patterns

Social Ties

Opinions
Digital Footprints of Human Activity

Shopping patterns

Social Ties

Opinions

Movements
Digital Footprints of Human Activity

- **Volume**: the incredible amounts of data generated each second
- **Velocity**: speed at which vast amounts of data are being generated, collected and analyzed
- **Variety**: the different types of data we can now use
- **Veracity**: quality or trustworthiness of the data
- **Value**: the worth of the data being extracted
Pappalardo et al., Returners and Explorers dichotomy in Human Mobility, Nature Communications 6, 8166 (2015).
https://doi.org/10.1038/ncomms9166
The rest of the city rises and leaves the house to begin a new day.
And our insight around driving behaviour increases second by second, minute by minute.
Ships trajectories: https://www.shipmap.org/
International migration flows
2005-2010

- number of migrants (inflows and outflows) in millions between and within world regions
- (only flows containing at least 170,000 migrants)

https://doi.org/10.1038/s41893-022-00903-x
What will you learn in GSA?
Module 1: Spatial and Mobility Data

- **Basic concepts**
  - Geographic coordinates systems, Vector data model

- **Data types**
  - Trajectory, Flows, Tessellations

- **Spatial and Mobility data**
  - Mobile Phone Records, GPS traces, Social media records, POIs, Road Networks

- **Preprocessing mobility data**
  - Filtering, compression, stop detection, trajectory segmentation, trajectory similarity and clustering

- **Practice: open-source tools for geospatial analysis**
  - Shapely, GeoPandas, folium, scikit-mobility, osmnx, and more
Module 2: Patterns and Laws

- Spatial analysis
  - point patterns, spatial autocorrelation, GWR
- Individual mobility patterns
- Collective mobility patterns
- Practice: analyze mobility data with scikit-mobility
Module 3: Predictive and Generative Models

- Prediction
  - Next-location prediction
  - Crowd flow prediction
  - Spatial interpolation

- Generation
  - Trajectory generation
  - Flow generation

- Practice: mobility prediction and generation in Python
Module 4: Applications

- Urban Segregation models
- Navigation Principles
- Estimating Pollution
Material

  - Chapter 1

- [paper] *Human Mobility: Models and Applications*, Barbosa et al., Physics Reports
  - Section 1 (Introduction)