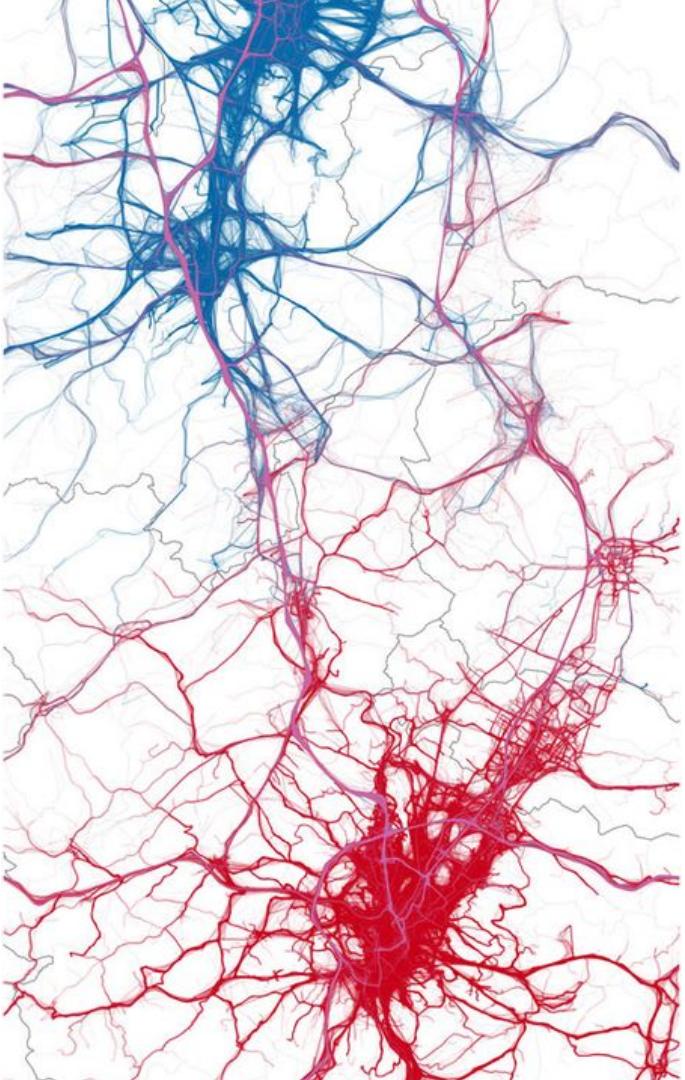


Consiglio Nazionale
delle Ricerche

01
Introduction

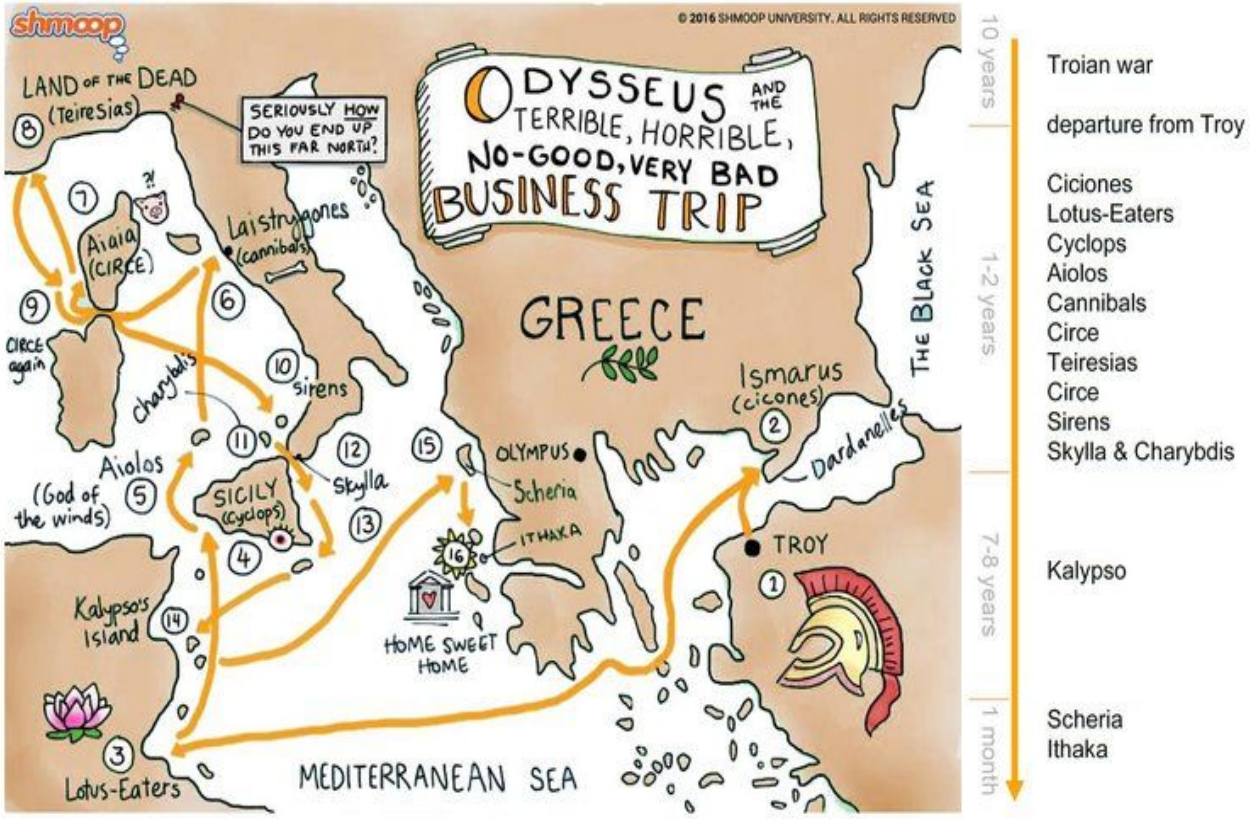
Geospatial Analytics

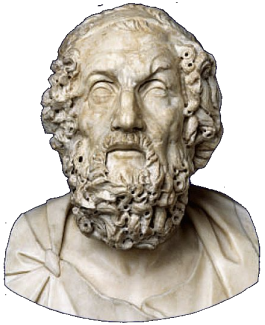
Transforming a (potentially large) set of isolated facts about ***when*** and ***where*** objects/people/phenomena **were** or **moved** into higher-level knowledge:

- 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



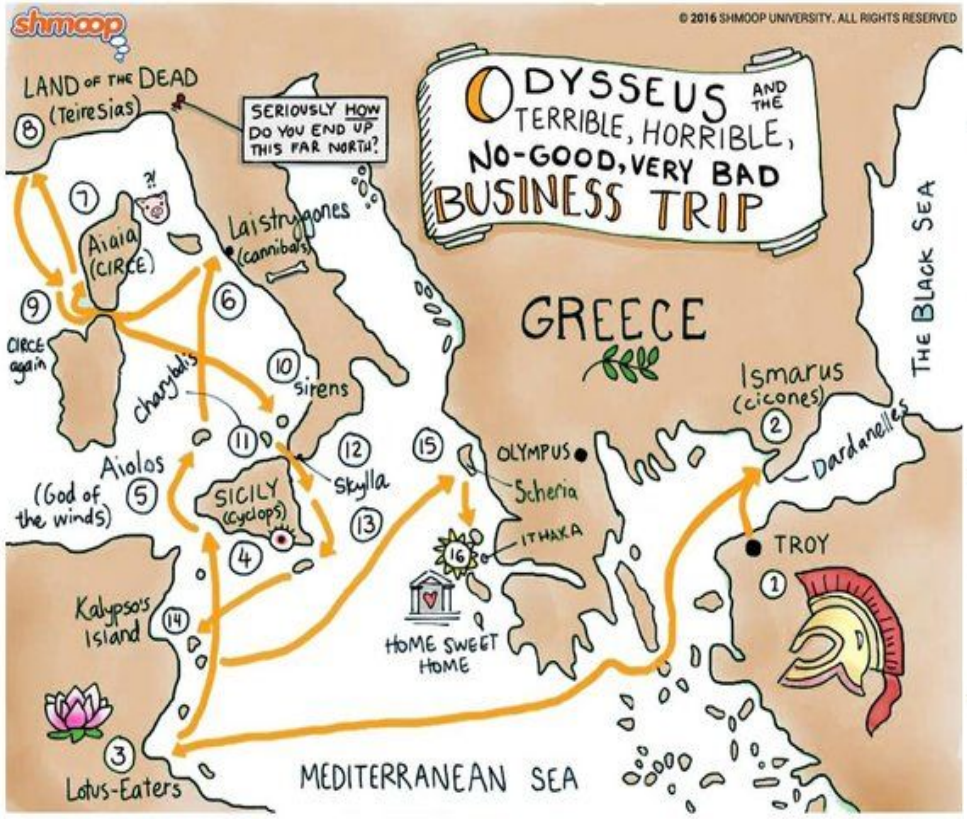


"A man who has been through bitter experiences and travelled far enjoys even his sufferings after a time"

Homer, Odyssey

interactive map

The Odyssey is the story of...a trajectory



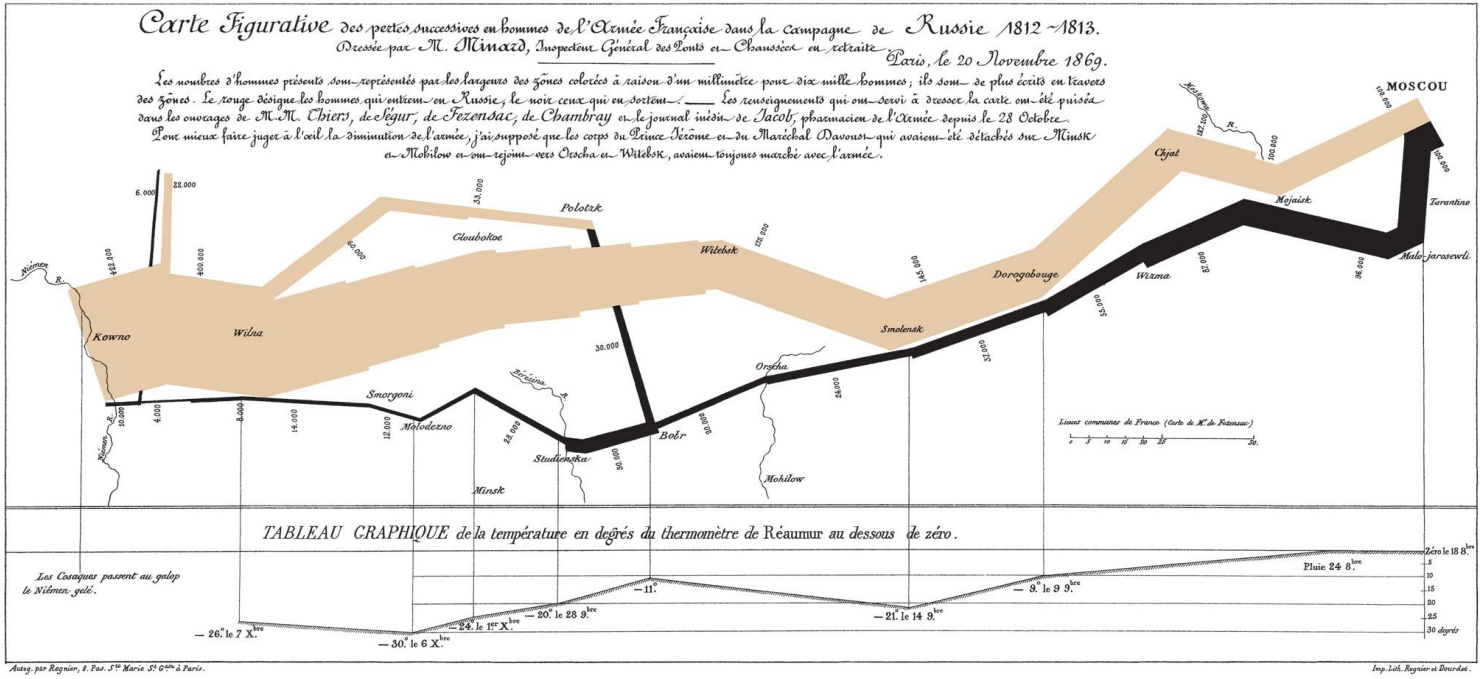
"ma misi me per l'alto mare aperto
sol con un legno e con quella compagna
picciola da la qual non fui diserto.
L'un lito e l'altro vidi infin la Spagna,
fin nel Morrocco, e l'isola d'i Sardi,
e l'altre che quel mare intorno bagna."

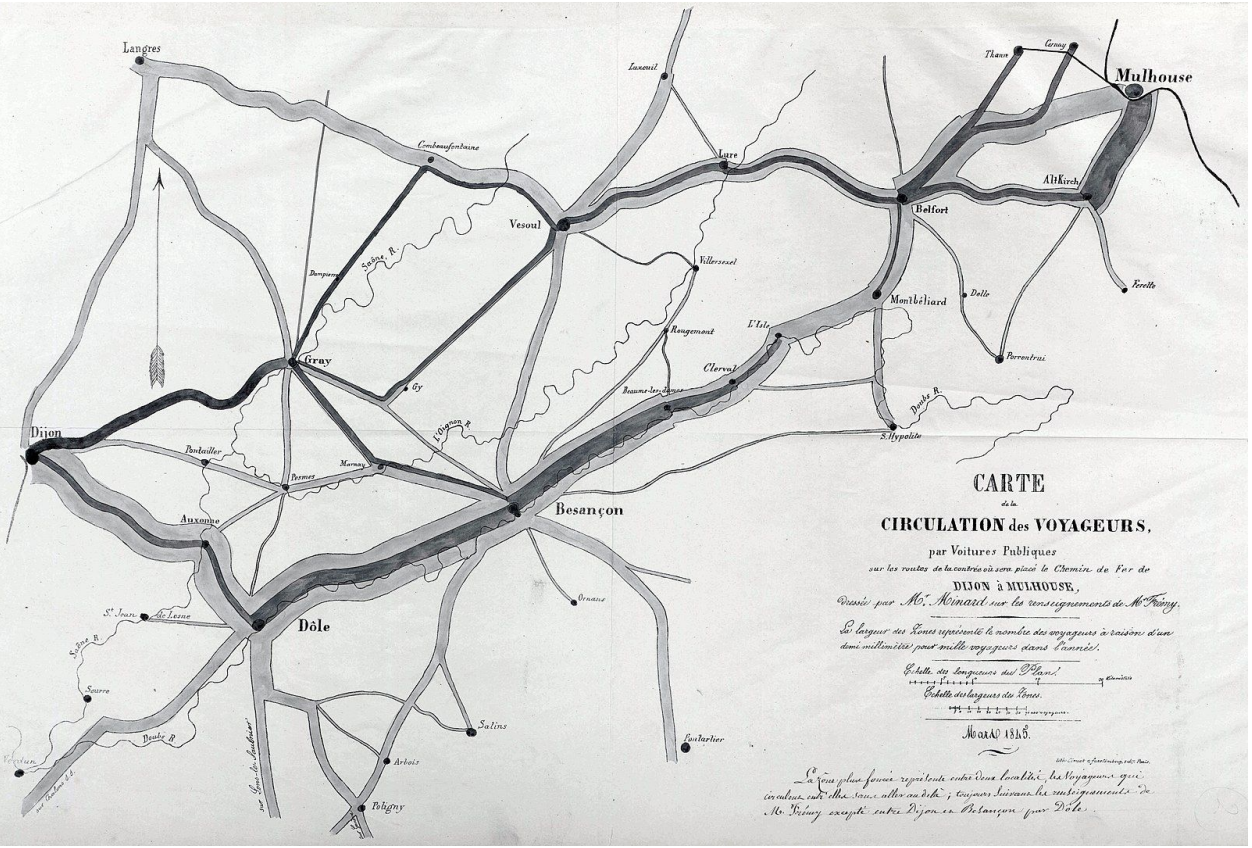
Dante's Inferno, Canto XXVI

interactive map

French army in the Russian campaign (1812-1813)

Charles Minard, 1869

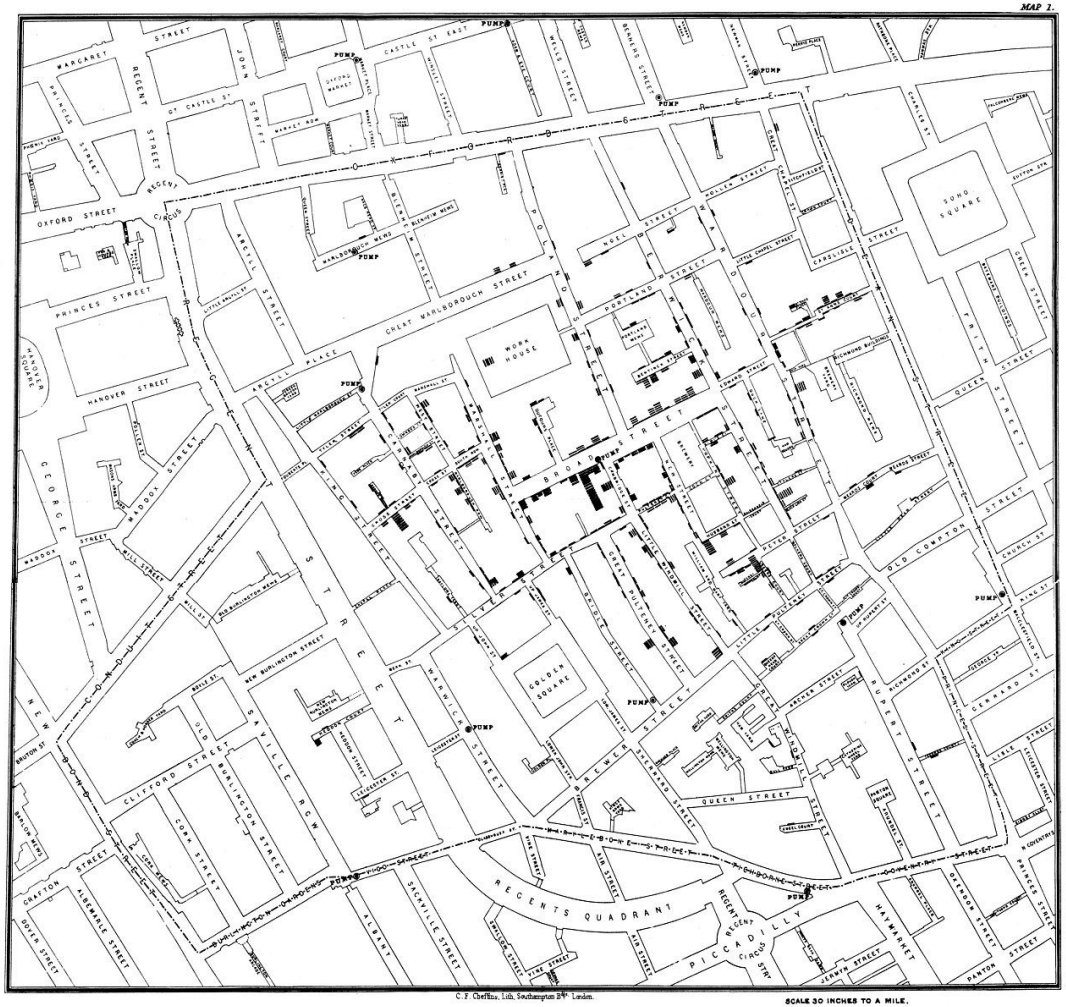




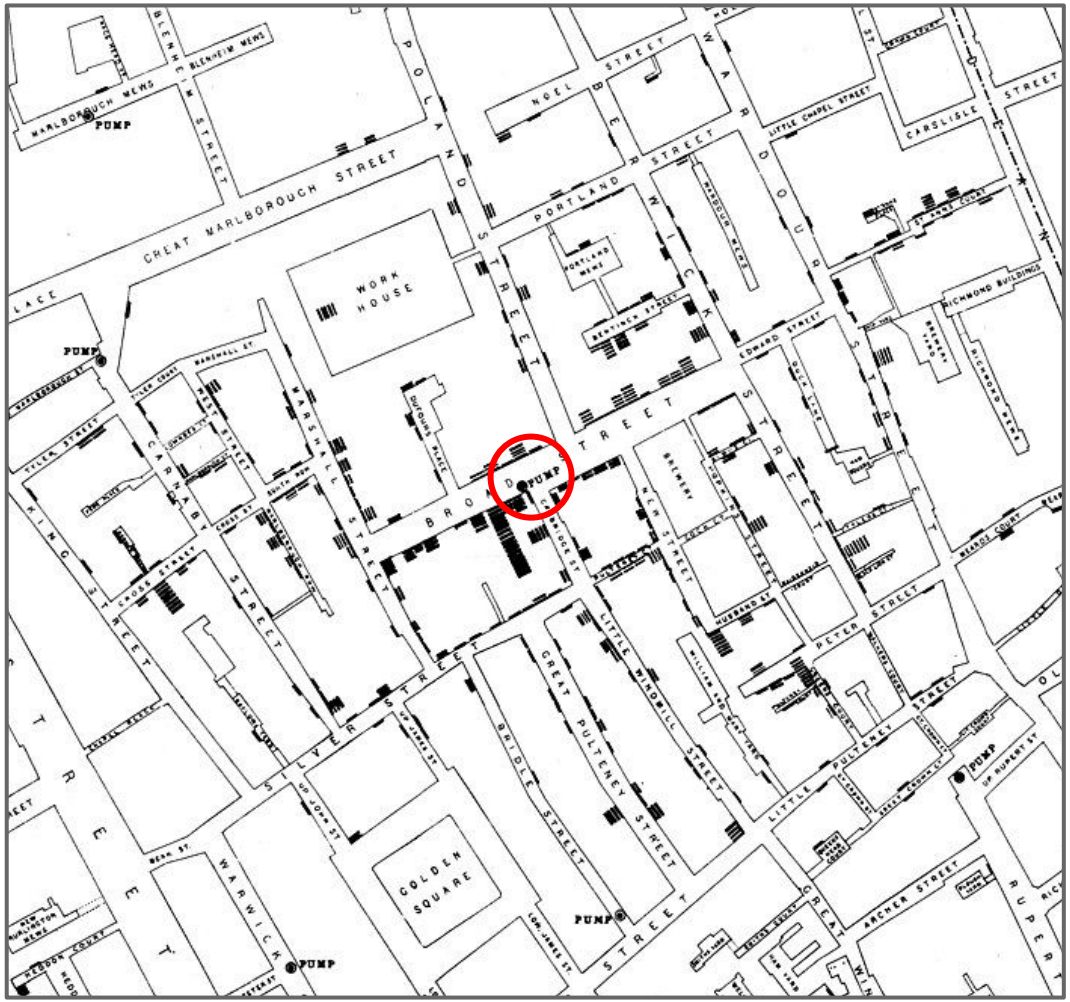
Number of passengers between Dijon and Mulhouse

Charles Minard, 1845

Spread of the Black Death (1346–1353)



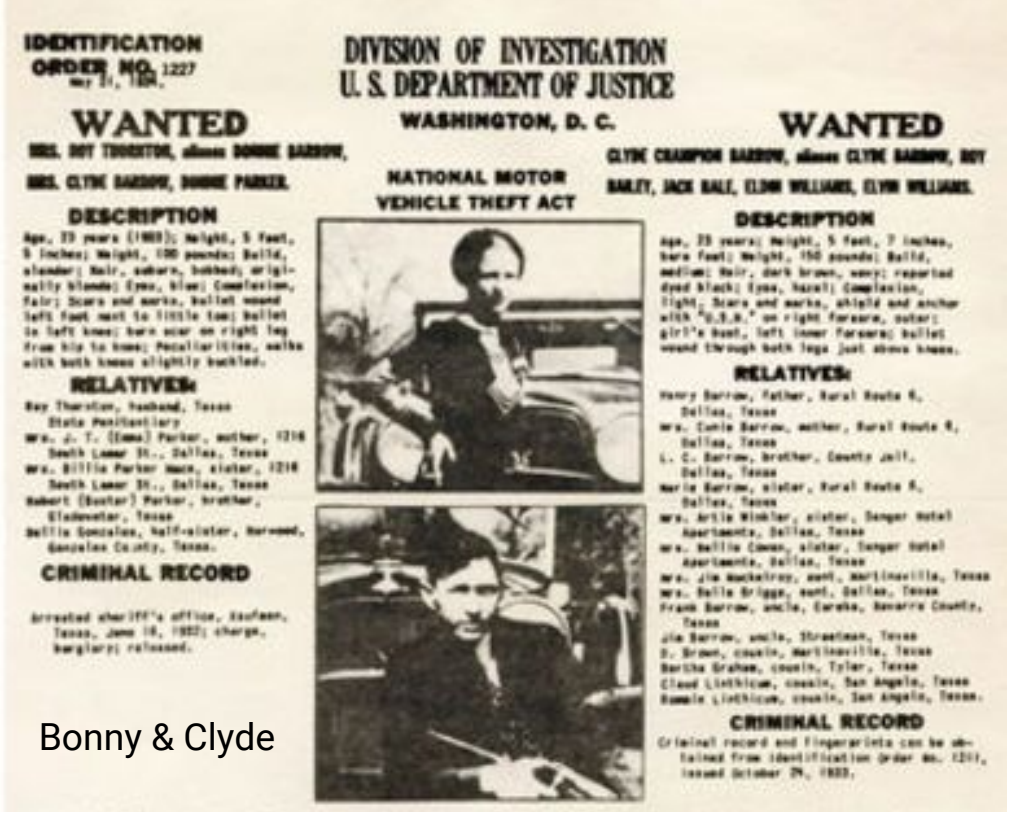
John Snow and the Broad Street cholera outbreak (1854)



John Snow and the Broad Street cholera outbreak (1854)

Predicting criminals' trajectory

1930s



IDENTIFICATION ORDER NO. 1227

DIVISION OF INVESTIGATION
U. S. DEPARTMENT OF JUSTICE
WASHINGTON, D. C.

WANTED

MRS. ROY THORNTON, alias DONNIE BARROW,
MRS. CLYDE BARROW, DONNIE PARKER.

DESCRIPTION

RELATIVES:

CRIMINAL RECORD

NATIONAL MOTOR VEHICLE THEFT ACT

WANTED

CLYDE CHAMPION BARROW, alias CLYDE BARROW, ROY BAILEY, JACK HALE, ELDIN WILLIAMS, ELVIN WILLIAMS.

DESCRIPTION

RELATIVES:

CRIMINAL RECORD

Bonny & Clyde

Predicting criminals' trajectory

1930s

The Bonny & Clyde task force

NIGHT THE DALLAS DISPATCH NIGHT
OUT OF CITY 5 CENTS IN DALLAS 5 CENTS
VOL. XXVIII, NO. 213 DALLAS, TEXAS, WEDNESDAY, MAY 23, 1934. TEN PAGES

CLYDE AND BONNIE RIDDLED WITH MACHINE GUN BULLETS

EDITORIAL

Shirley's Opening Address

REAL STATESMANSHIP as well as efforts at political vote-getting sustained characterized the opening speech for the United States Senate by Senator T. J. Bailey, D. The outstanding point was his hearty approval of revision of the tariff downward. Built up unreasonably by various Republican congresses, the tariff wall has been erected a height that diversity and uniformity have prevailed the volume of U. S. foreign trade from five billions a year to a scant billion and a half.

Texas, the largest exporting state in the Union, Bailey's native state, the heart and home of real democracy, has probably suffered most from this abnormal policy.

Secretary Wallace's assertion that 40 million workers would be benefitted by restored tariff trade with 40 million might suffer temporarily clearly shows where the greatest need in the present instance is to be found.

The empowerment to distinctly on the right track as to tariff changes, and he did well to emphasize that point in his first formal appeal to the Democrats of Texas.

On the payment commodity of the tariff, the partial announcements of others, there will not be able to follow Bailey, the a large voting element will give him three cheers on three planks, and he knows it.

His opposition to the Black-Connery bill on the grounds of the state's rights is to be commended. It is the principle of the Democratic father. Perhaps one of the best points he made was as to the independent offices bill, to which he reminded the presidential who, when he said:

"I thought the bill was fair and just and right. I voted for the bill all the way thru. My entire record of public service is what I stood by when I believed it was right and just."

When this and many other congress items is read who vote on principle and conviction and stick to them, regardless of expediency and politics, Congressman Bailey did well to bring out this point, especially at this time.

Free Speech Denied

IT IS in such circumstances as the Tarrant county case that Thomas was jailed and not permitted to speak after he had been duly authorized to [illegible] Dallas citizens, the old Tarrant county case of Senator Joe Bailey, just as Thomas was, [illegible] in Fannin, p. 15, are a dim memory. [illegible] for the privilege of free speech [illegible]

JONES HAPPY--FREE NOW FROM CLYDE'S ANGER

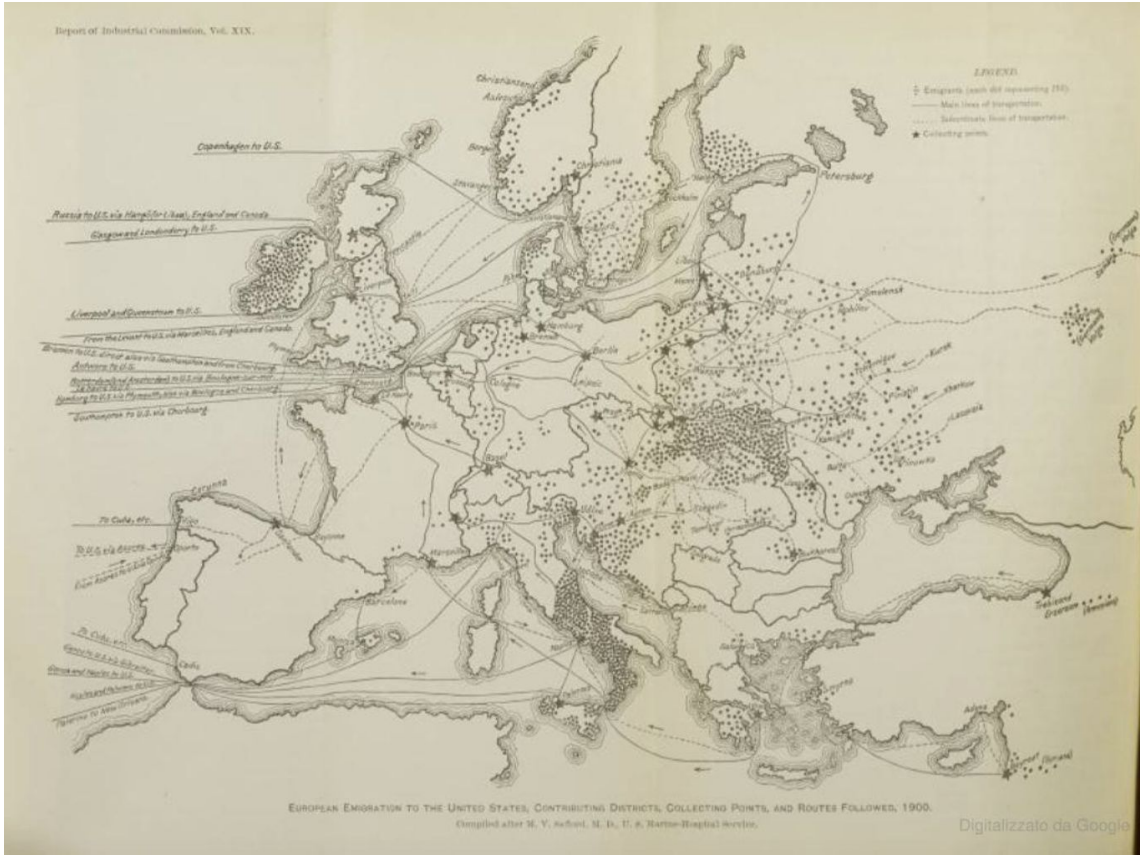
Youngster's Eyes Show Wild Excitement as He Hears News Wednesday.

HOPES FOR FREEDOM

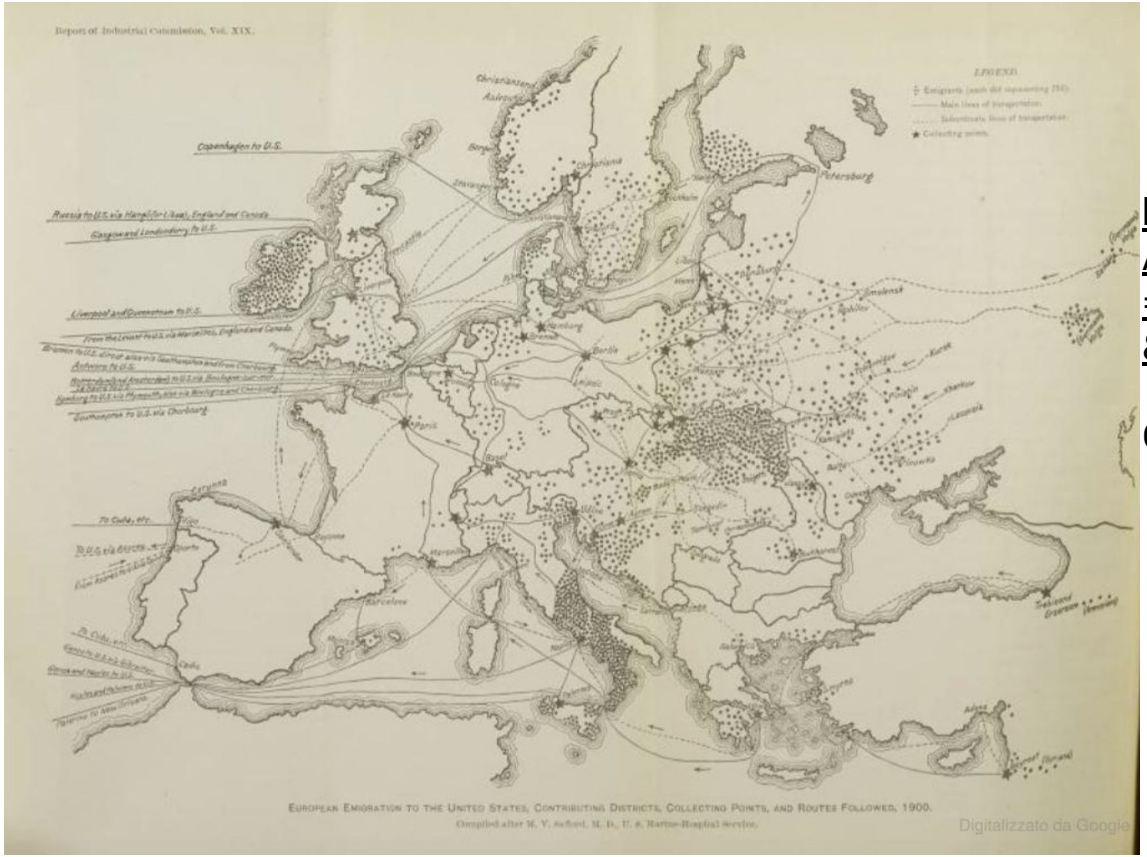
Under Indictment for Two Killings, but Sees Chance Of Liberty Ahead.

W. D. Jones, 15, who came to [illegible] Wednesday [illegible] Wednesday night, who [illegible] of the [illegible] Clyde Barrow [illegible] [illegible] [illegible]

Ravenstein


Report of Industrial Commission, Vol. XIX.
LEGEND.
Copenhagen to U.S.
Russia to U.S. via Hangö (or Libau), England and Canada
Glasgow and Londonderry to U.S.
Liverpool and Queenstown to U.S.
Antwerp to U.S.
Southampton to U.S. via Cherbourg
Christiansand
Aalesund
Christiania
Petersburg
Smolensk
Hamburg
Berlin
Paris
Cologne
Bayonne
Barcelona
Cadiz
Adana
European Emigration to the United States, Contributing Districts, Collecting Points, and Routes Followed, 1900.
Compiled after M. V. Safford, M. D., U. S. Marine-Hospital Service.
Digitalizzato da Google

Immigrants to US from Europe



EUROPEAN EMIGRATION TO THE UNITED STATES, CONTRIBUTING DISTRICTS, COLLECTING POINTS, AND ROUTES FOLLOWED, 1900.

Compiled after M. Y. Ashford, M. D., U. S. Marine-Hospital Service.

https://books.google.ie/books?id=SCZJAQAAMAAJ&printsec=frontcover&hl=it&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

Chapter: Immigration

Animal tracking

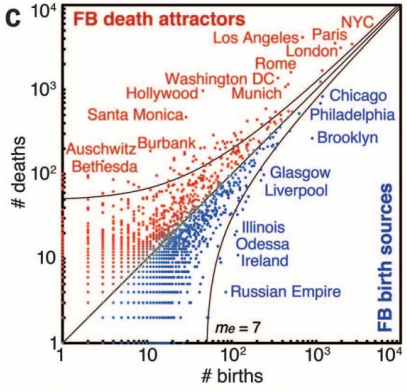
Tracking the movements of dissidents

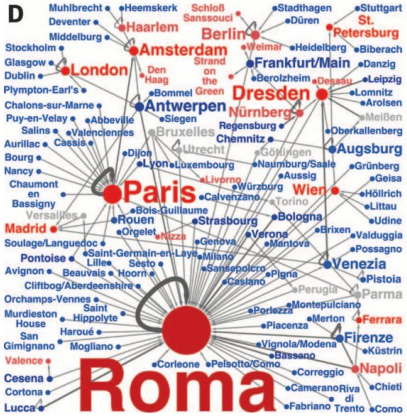
1970s-1980s

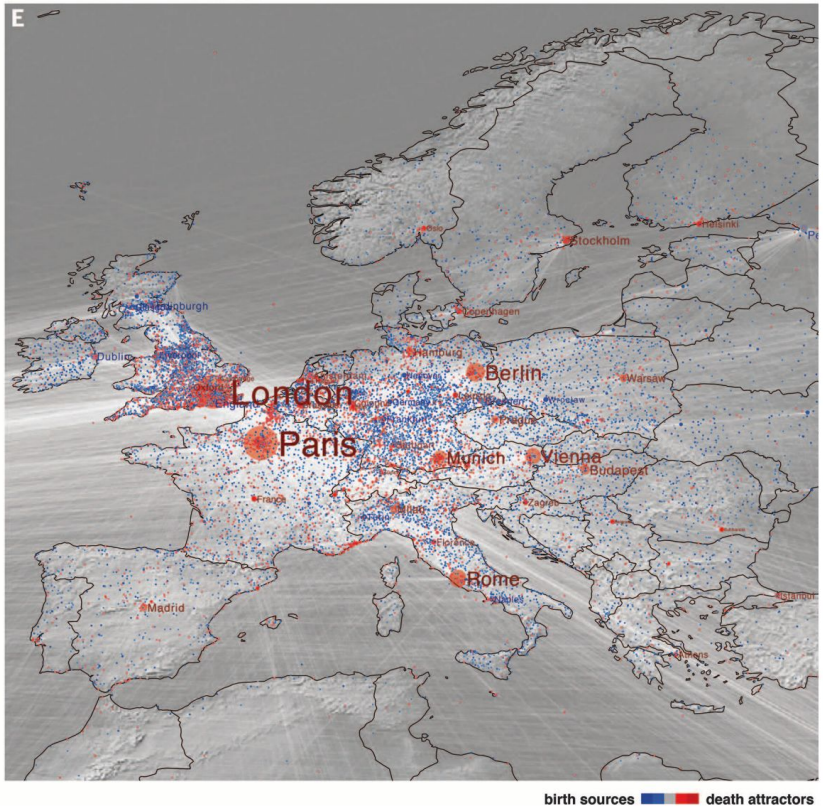
- Stasi sprayed a ***radioactive solution*** on the floors of the rooms where suspected dissidents met
- The solution adhered to dissidents' shoes, allowing agents to **track who attended a meeting** there
- Agents wore portable Geiger counters that activate when a suspected dissident was nearby

NewScientist

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

2005
Luca Bruno / AP
2013
NBC NEWS
Michael Sohn / AP

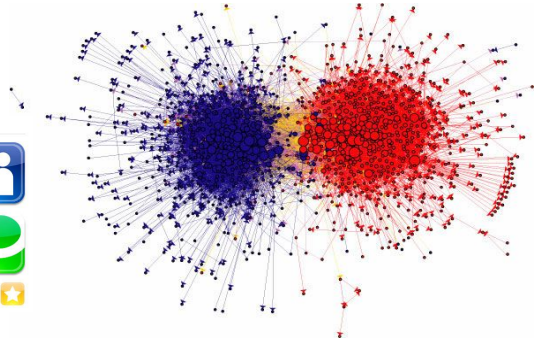
Digital Footprints of Human Activity

Shopping patterns

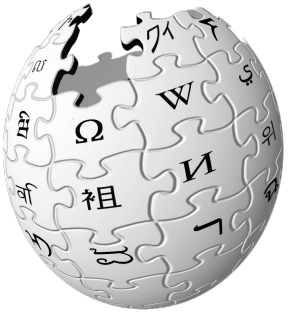
Digital Footprints of Human Activity

Shopping patterns

Social Ties



Opinions

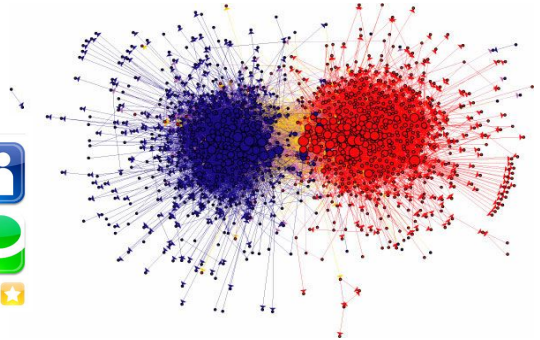


WIKIPEDIA
The Free Encyclopedia

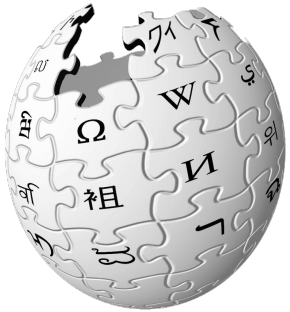
Digital Footprints of Human Activity

Shopping patterns

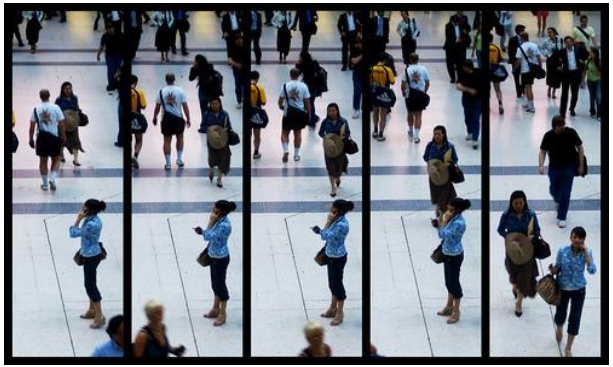
Social Ties



Opinions

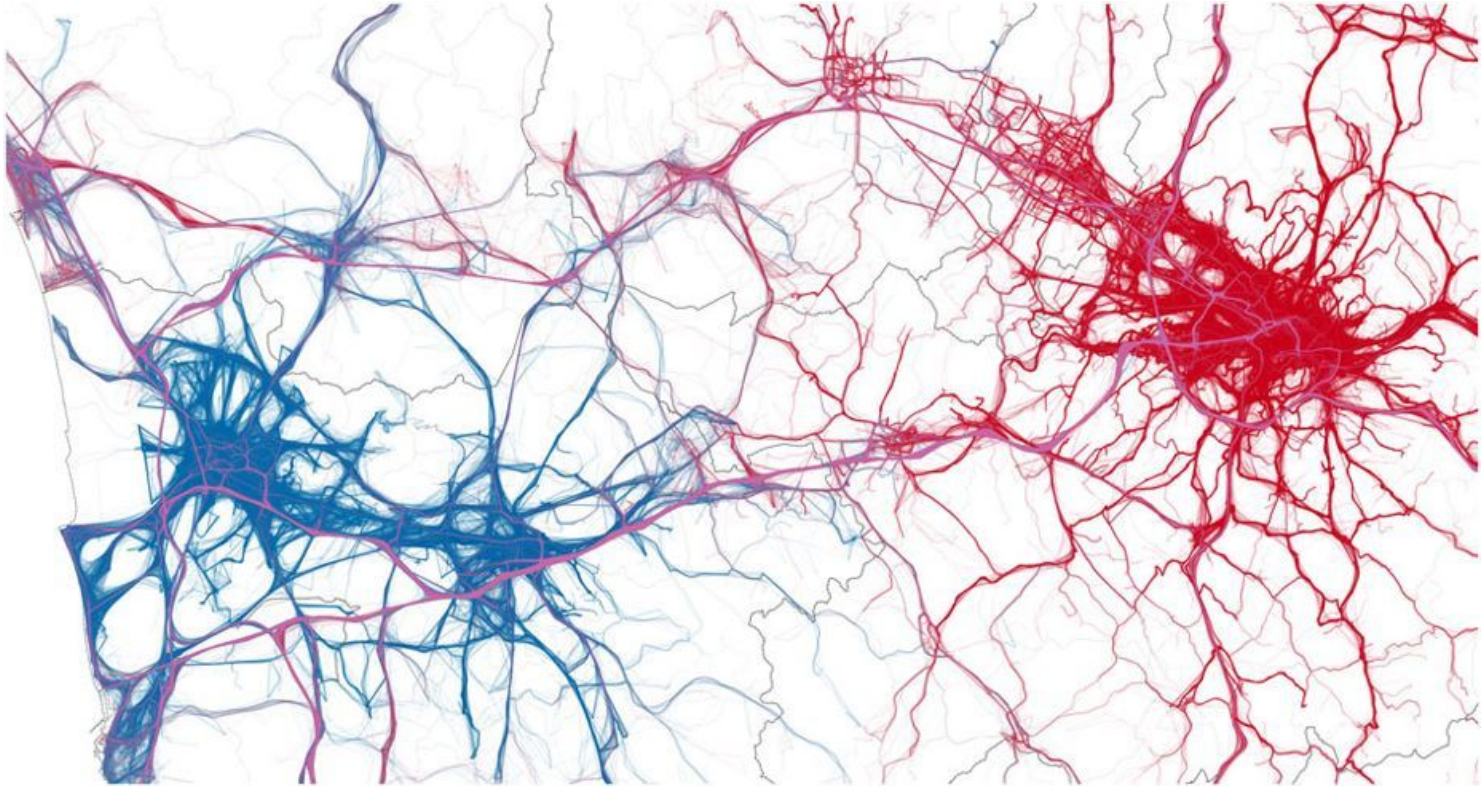


Movements



Digital Footprints of Human Activity

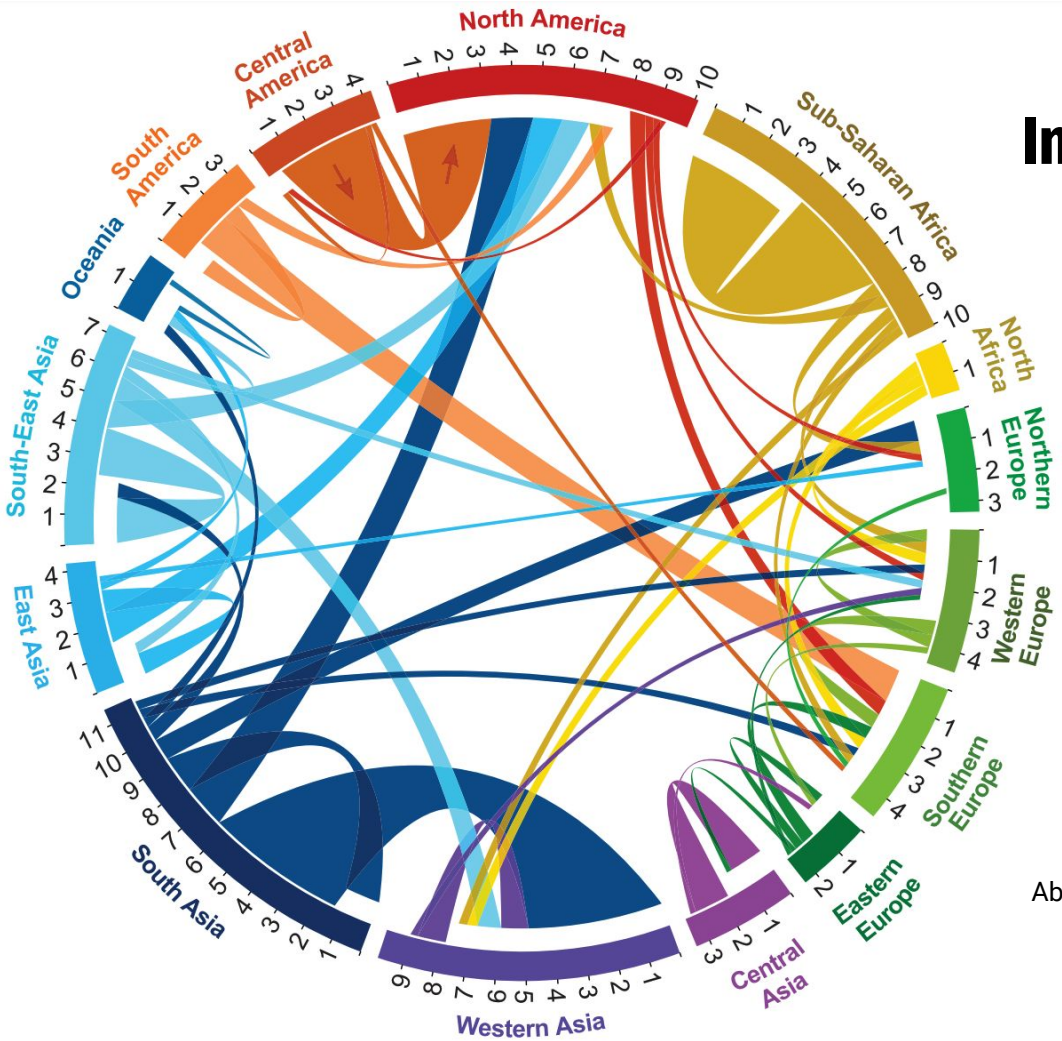
- **Volume**: the incredible amounts of data generated each second
- **Velocity**: speed at which vast amounts of data are being generated, collected and analyzed
- **Variety**: the different types of data we can now use
- **Veracity**: quality or trustworthiness of the data
- **Value**: the worth of 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

Wembley
Olympic Park
Big Ben
Wimbledon
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/

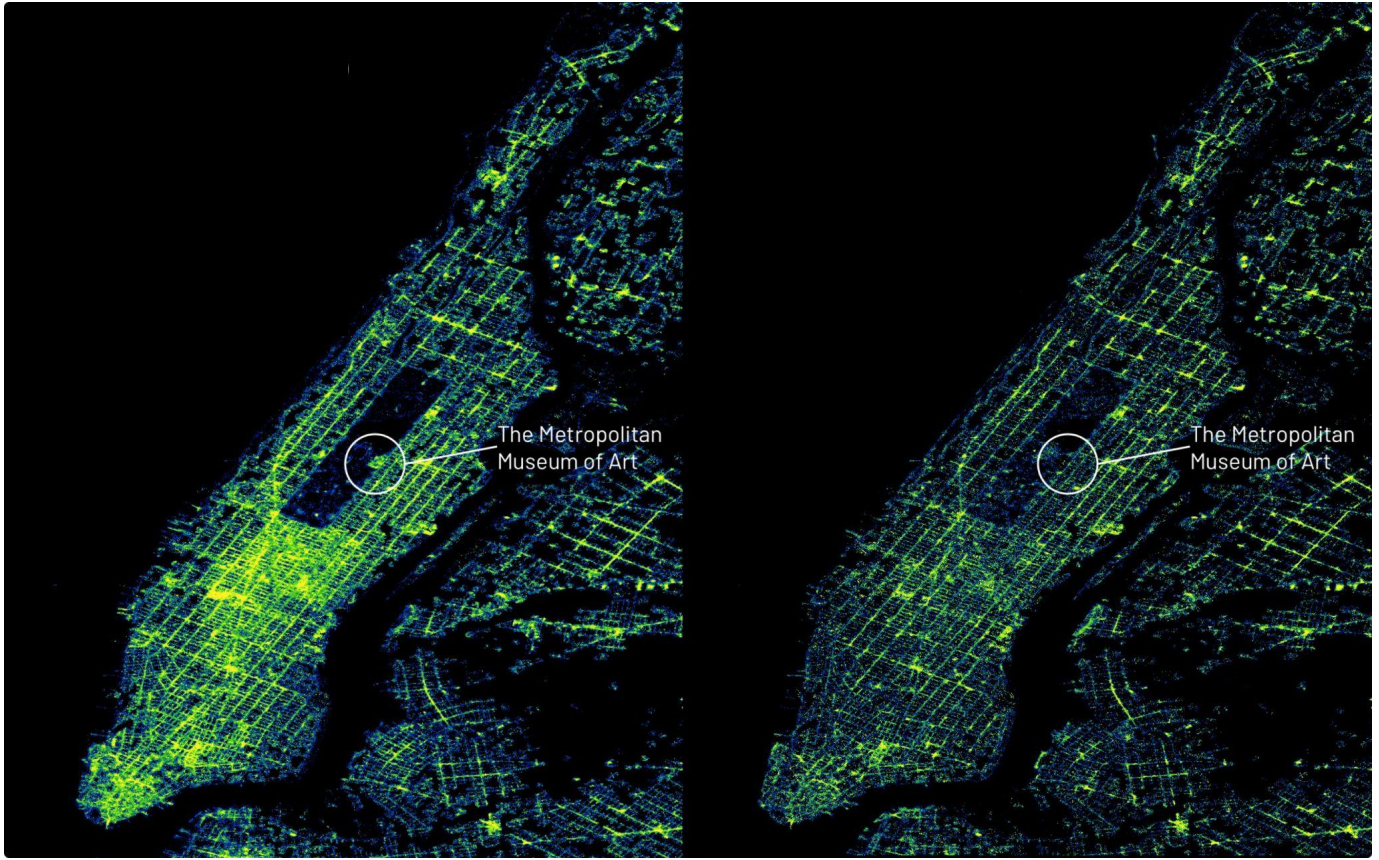


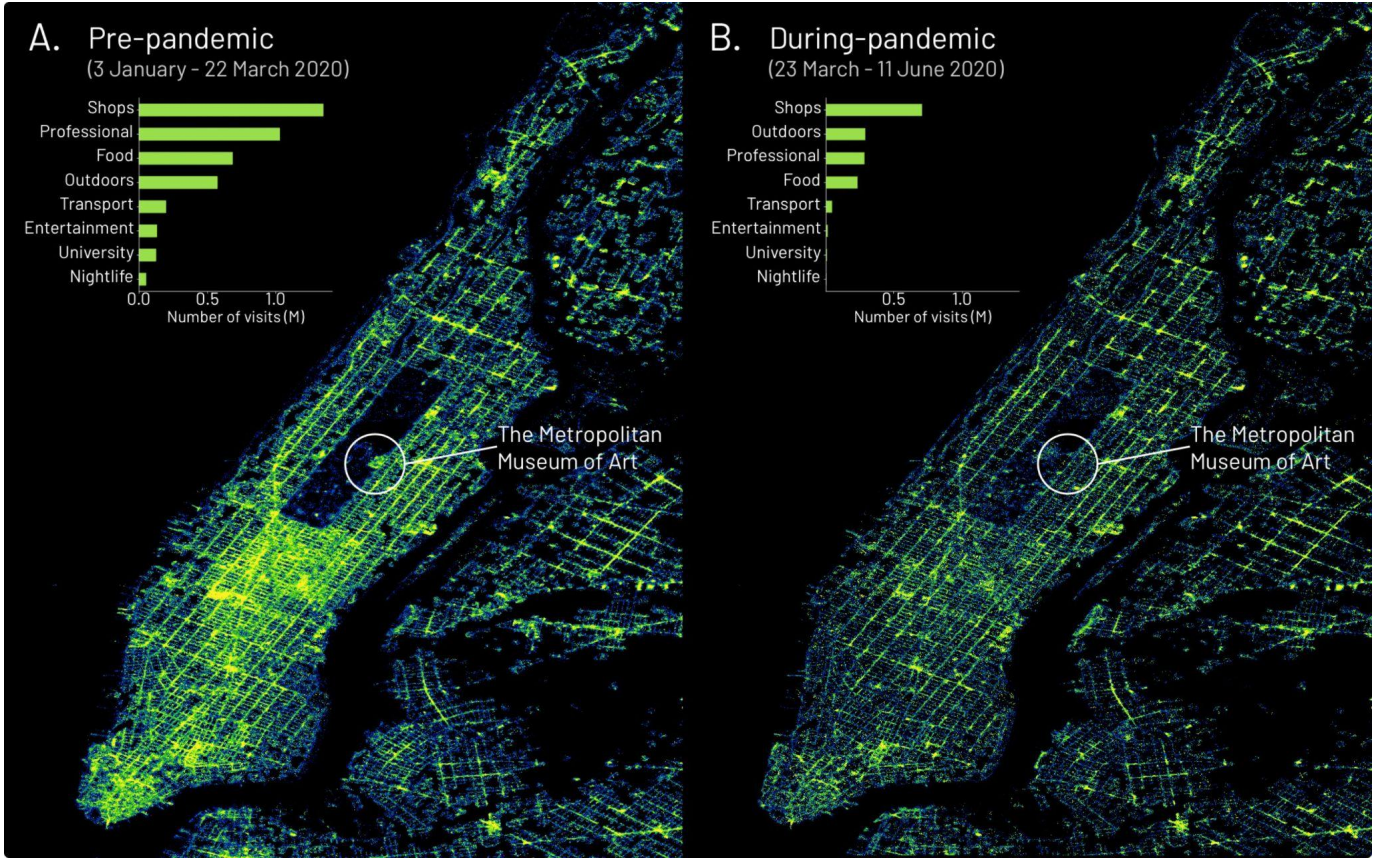
International migration flows

2005-2010

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

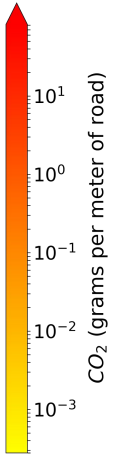
Abel and Sander, Quantifying global international migration flows, Science 343.6178 (2014): 1520-1522.

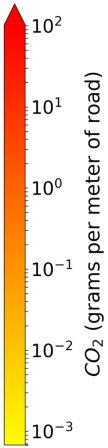

The Metropolitan
Museum of Art
The Metropolitan
Museum of Art



Lucchini et al., Living in a pandemic: changes in mobility routines, social activity and adherence to COVID-19 protective measures. Scientific Reports 11, 24452 (2021). https://doi.org/10.1038/s41598-021-04139-1

CO2 emissions on roads





Böhm et al. Gross polluters and vehicle emissions reduction. Nature Sustainability 5, 699–707 (2022).
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

- Human mobility & epidemic spreading (COVID-19)
- Urban Segregation models
- Navigation Principles
- Estimating Pollution
- AI & Mobility

Material (What to read & study for the exam)

- [book] Introduction to geographic information systems, Kang-Tsung Chang, McGraw-Hill
  - Chapter 1

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