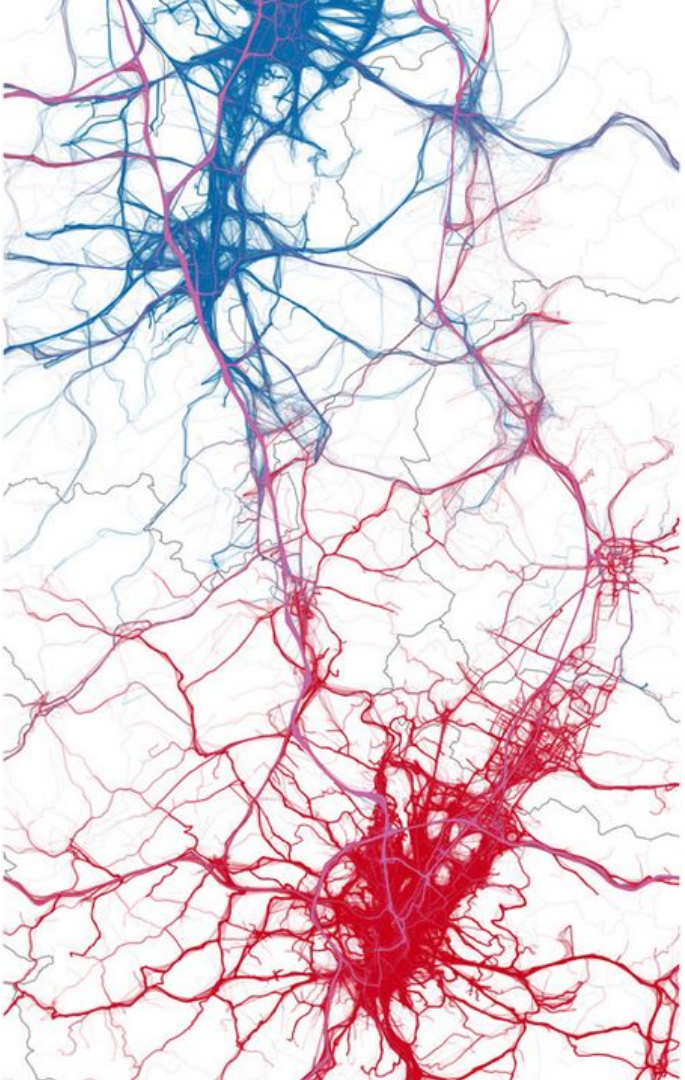


Consiglio Nazionale
delle Ricerche

01
Introduction

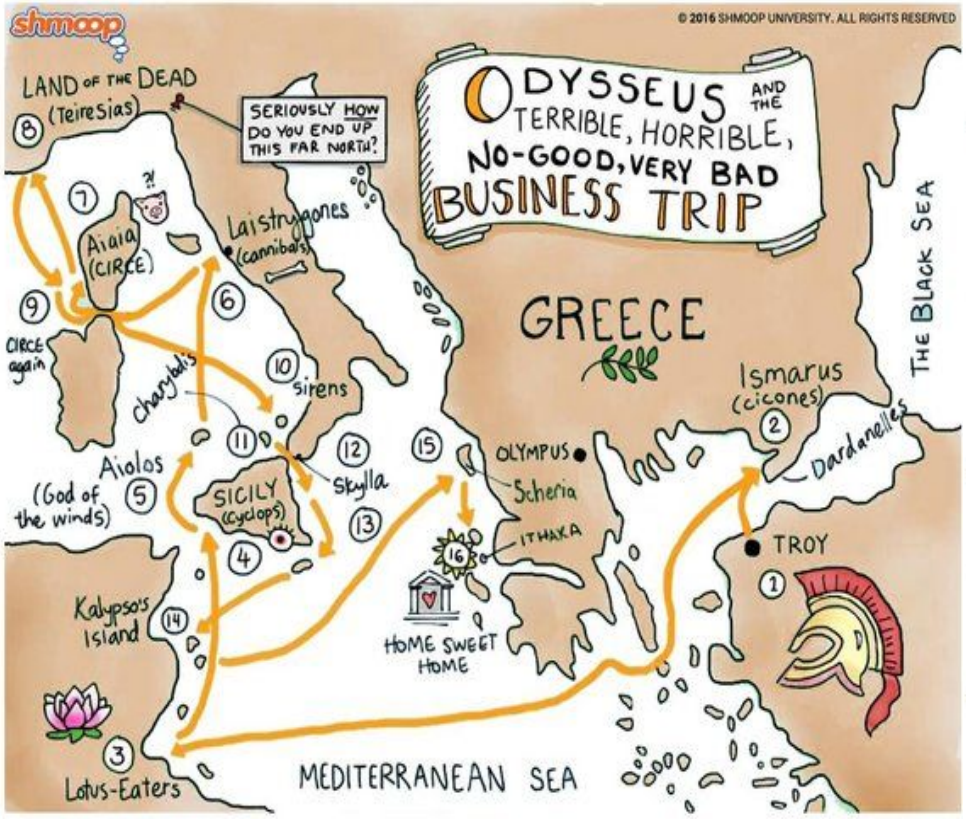
Geospatial Analytics

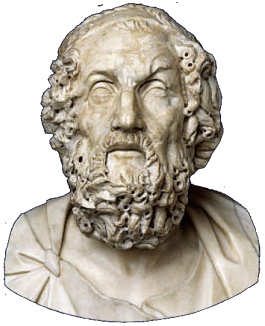
Transforming a (potentially large) set of isolated facts about ***when*** and ***where*** objects/people/phenomena **were** or **moved** into higher-level knowledge:

- 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



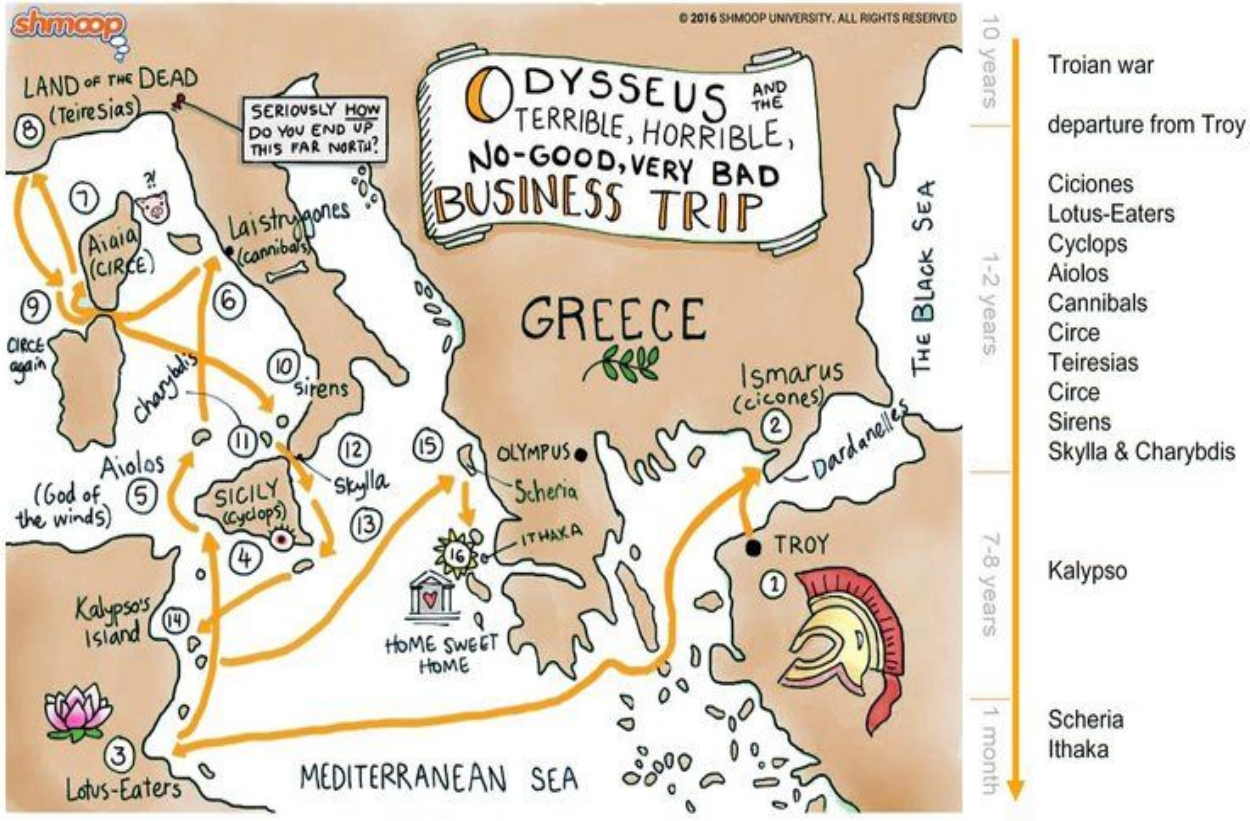


"A man who has been through bitter experiences and travelled far enjoys even his sufferings after a time"

Homer, Odyssey

interactive map

The Odyssey is the story of...a trajectory



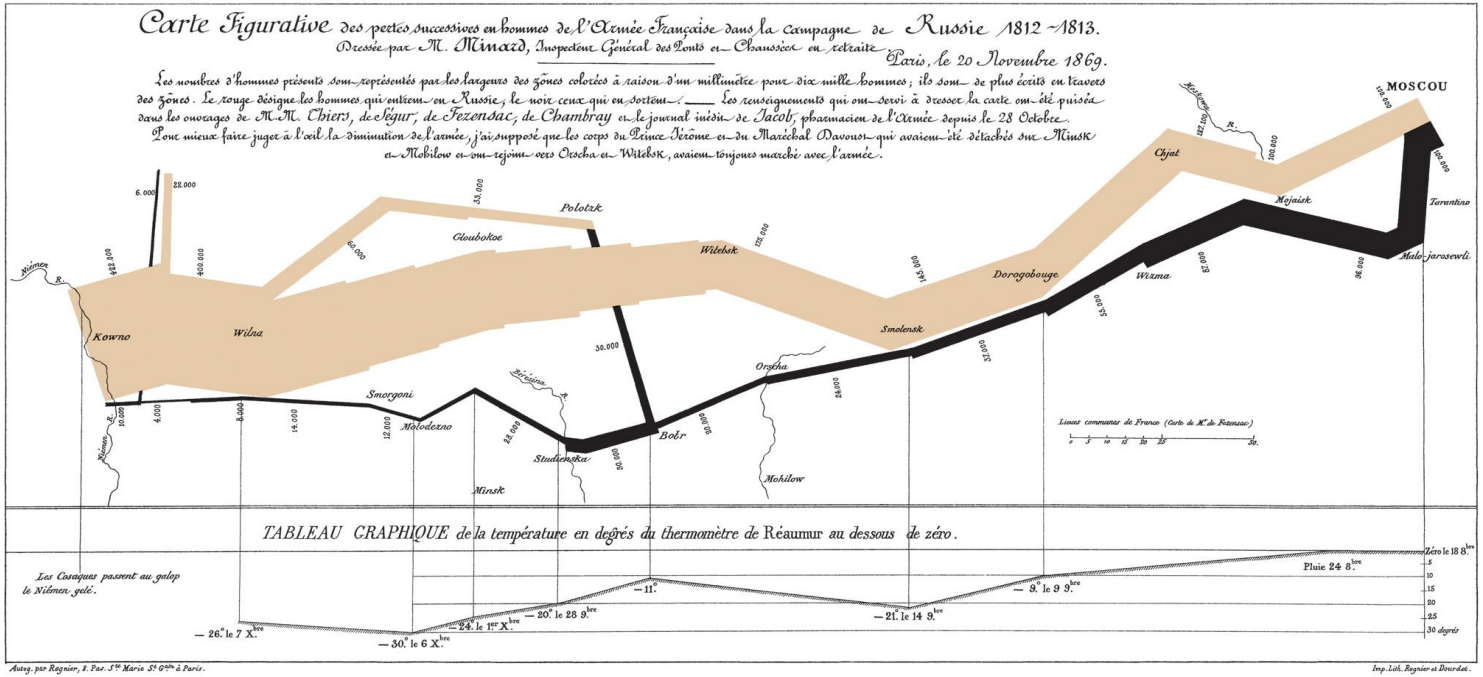
"ma misi me per l'alto mare aperto
sol con un legno e con quella compagna
picciola da la qual non fui diserto.
L'un lito e l'altro vidi infin la Spagna,
fin nel Morrocco, e l'isola d'i Sardi,
e l'altre che quel mare intorno bagna."

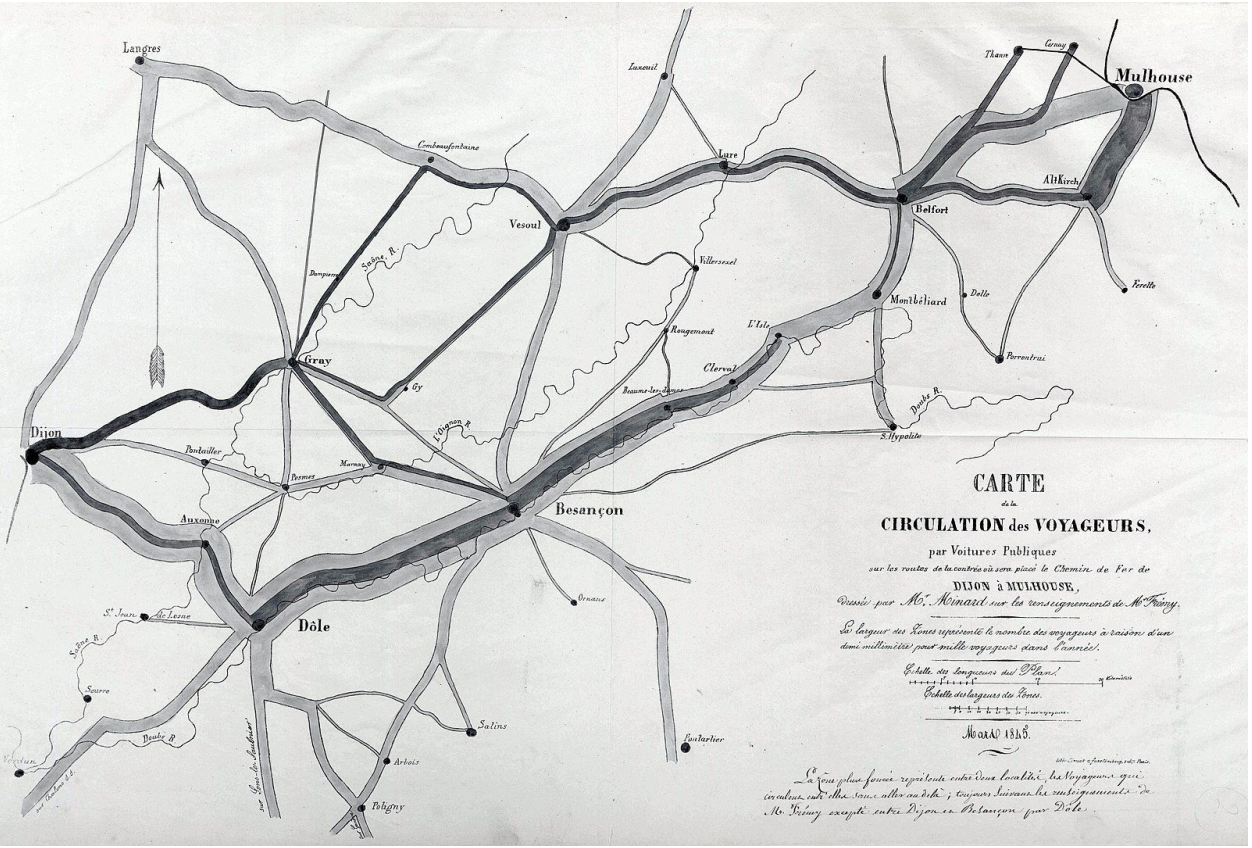
Dante's Inferno, Canto XXVI

interactive map

French army in the Russian campaign (1812-1813)

Charles Minard, 1869





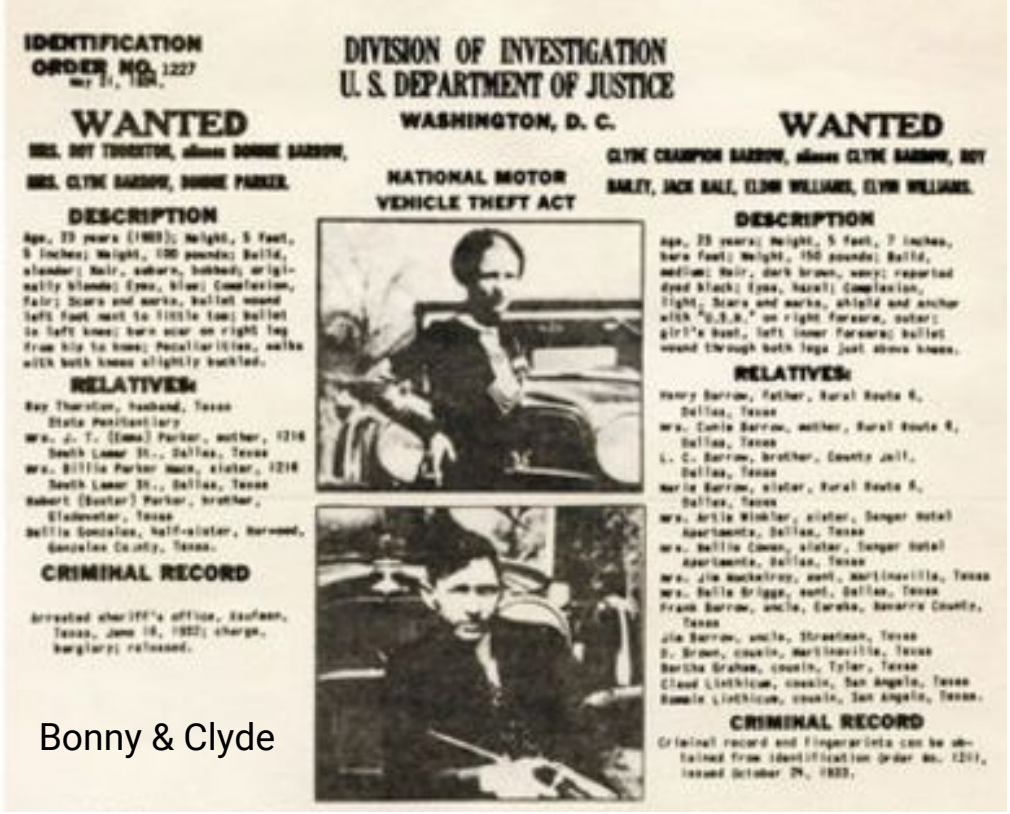
Number of passengers between Dijon and Mulhouse

Charles Minard, 1845

Spread of the Black Death (1346–1353)

Predicting criminals' trajectory

1930s



IDENTIFICATION ORDER NO. 1227

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

WANTED

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

NATIONAL MOTOR VEHICLE THEFT ACT

DESCRIPTION

Age, 23 years (1933); Height, 5 feet, 5 inches; Weight, 100 pounds; Build, slender; Hair, auburn, bobbed; originally blonde; Eyes, blue; Complexion, fair; Scars and marks, bullet wound left foot next to little toe; bullet in left knee; burn scar on right leg from hip to knee; Peculiarities, walks with both knees slightly buckled.

RELATIVES:

Roy Thornton, husband, Texas State Penitentiary
Mrs. J. T. (Emma) Parker, mother, 1216 South Lamar St., Dallas, Texas
Mrs. Billie Parker Mace, sister, 1216 South Lamar St., Dallas, Texas
Hubert (Buster) Parker, brother, Gladewater, Texas
Nellie Gonzales, half-sister, Harwood, Gonzales County, Texas.

CRIMINAL RECORD

Arrested sheriff's office, Kaufman, Texas, June 16, 1932; charge, burglary; released.

Bonny & Clyde

WANTED

CLYDE CHAMPION BARROW, alias CLYDE BARROW, ROY BAILEY, JACK BALE, ELMER WILLIAMS, ELVIN WILLIAMS.

DESCRIPTION

Age, 23 years; Height, 5 feet, 7 inches, bare feet; Weight, 150 pounds; Build, medium; Hair, dark brown, wavy; reported dyed black; Eyes, hazel; Complexion, light; Scars and marks, athlete and anchor with "U.S.N." on right forearm, outer; girl's bust, left inner forearm; bullet wound through both legs just above knees.

RELATIVES:

Henry Barrow, father, Rural Route 6, Dallas, Texas
Mrs. Cumie Barrow, mother, Rural Route 6, Dallas, Texas
L. C. Barrow, brother, County Jail, Dallas, Texas
Marie Barrow, sister, Rural Route 6, Dallas, Texas
Mrs. Artie Winkler, sister, Denger Hotel Apartments, Dallas, Texas
Mrs. Nellie Cowan, sister, Denger Hotel Apartments, Dallas, Texas
Mrs. Jim Mackatrey, aunt, Martinsville, Texas
Mrs. Nelle Briggs, aunt, Dallas, Texas
Frank Barrow, uncle, Eureka, Navarro County, Texas
Jim Barrow, uncle, Streetman, Texas
D. Brown, cousin, Martinsville, Texas
Bertha Graham, cousin, Tyler, Texas
Claud Lichlicum, cousin, San Angelo, Texas
Romelo Lichlicum, cousin, San Angelo, Texas.

CRIMINAL RECORD

Criminal record and fingerprints can be obtained from identification Order No. 1227, issued October 24, 1933.

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

Shaller's Opening Address

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.

Texas Murdering Pair and Three Officers Who Stopped Their Career

Clyde and Bonnie—a killer and his gun-girl

MRS. PARKER HYSTERICAL AT NEWS OF DEATH

GOD HAVE MERCY ON HIS SOUL, SOBS MOTHER

DALLAS OFFICERS HELP SHOOT DOWN PAIR IN LOUISIANA

Arcadia, La., May 23.—The bodies of Clyde Barrow, southwest's most desperate gunman, and his companion, Bonnie Parker, lay in a morgue here today after they were killed in a battle with four Texas and two Louisiana officers.

The Texas outlaw, reared in west Dallas, was riddled with bullets from machine gun, rifle and shotgun fire. Both he and Bonnie Parker had each been shot 50 times or more.

The pair was ambushed early today in a trap Sheriff Schmid of Dallas and his deputies had set for them six weeks ago. In the party of six officers who poured a stream of slugs into their bodies were Deputies Ted Hinton and Bob Alcorn of Dallas, Frank Hamer, former Texas ranger, and N. T. Gault, former Texas ranger and member of the state highway department, and two Louisiana officers.

The Louisiana rendezvous had been discovered by Sheriff Schmid and careful plans have been laid to trap them.

Both bodies were identified by the officers. A coroner's inquest held this afternoon said they had come to their deaths from "gunshot wounds." The big toe of Barrow was missing, cut off by himself to escape work while a prison farm convict.

The following version of the gun fight was given by Frank Hamer:

"There wasn't much to it. We set a trap. They ran into it as we sprung it.

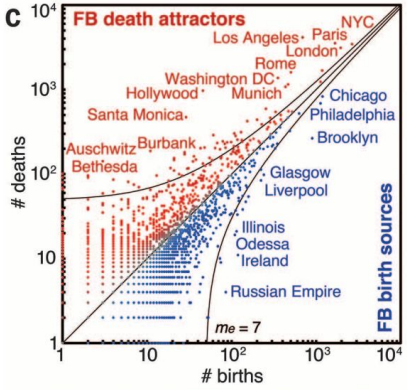
Tracking the movements of dissidents

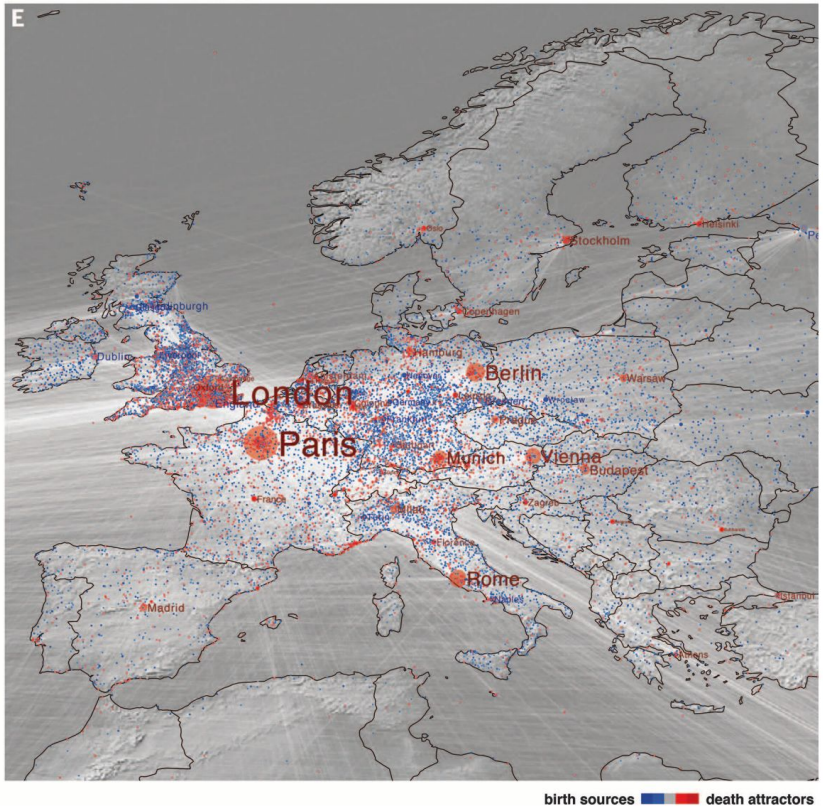
1970s-1980s

- 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

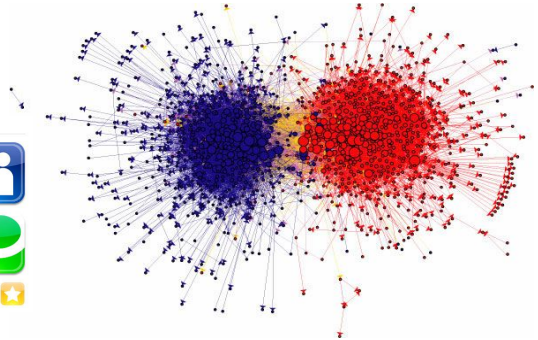
Digital Footprints of Human Activity

Shopping patterns

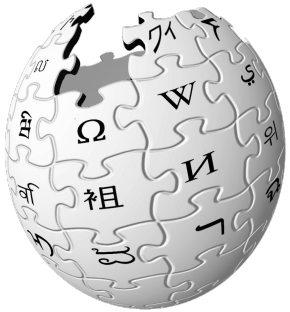
Digital Footprints of Human Activity

Shopping patterns

Social Ties



Opinions

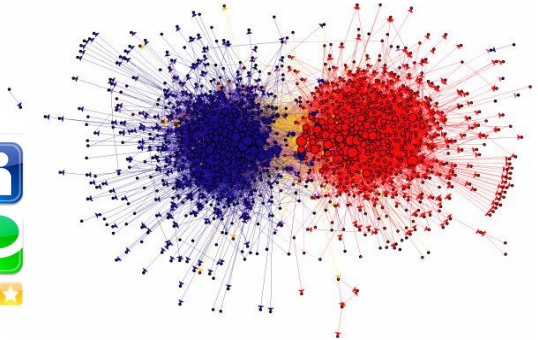


WIKIPEDIA
The Free Encyclopedia

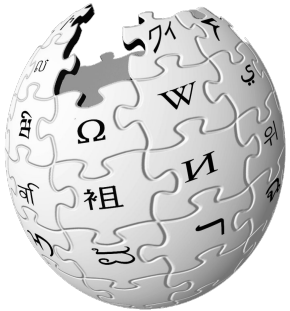
Digital Footprints of Human Activity

Shopping patterns

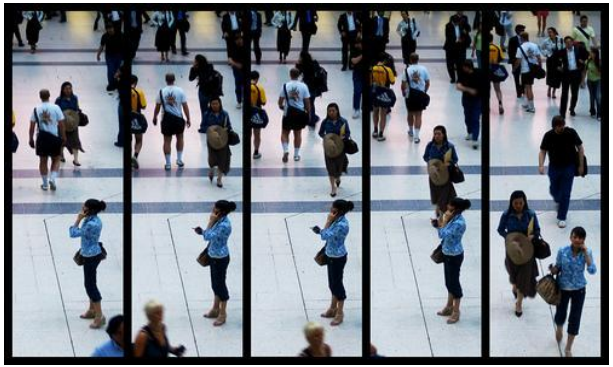
Social Ties



Opinions

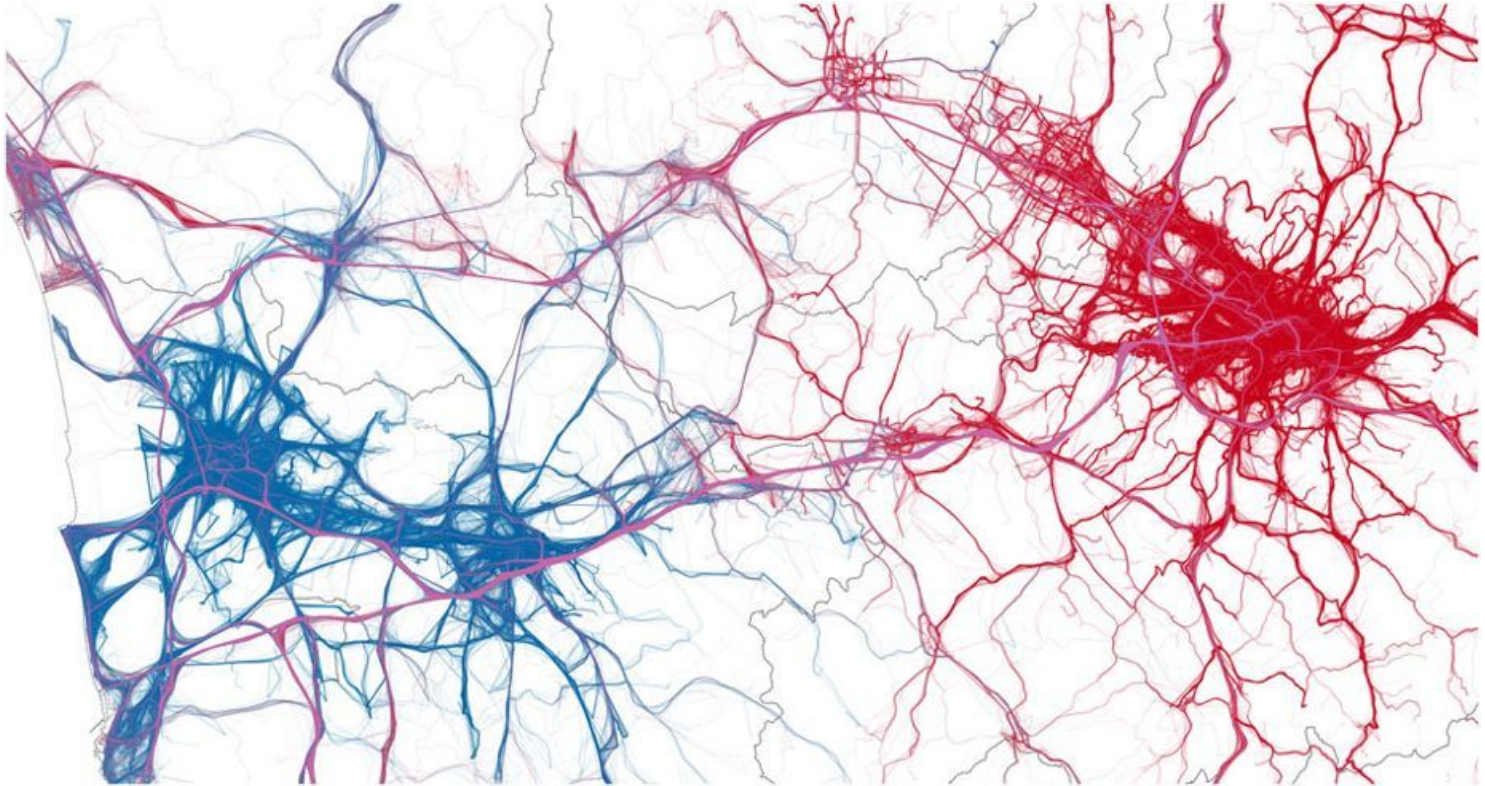


Movements



Digital Footprints of Human Activity

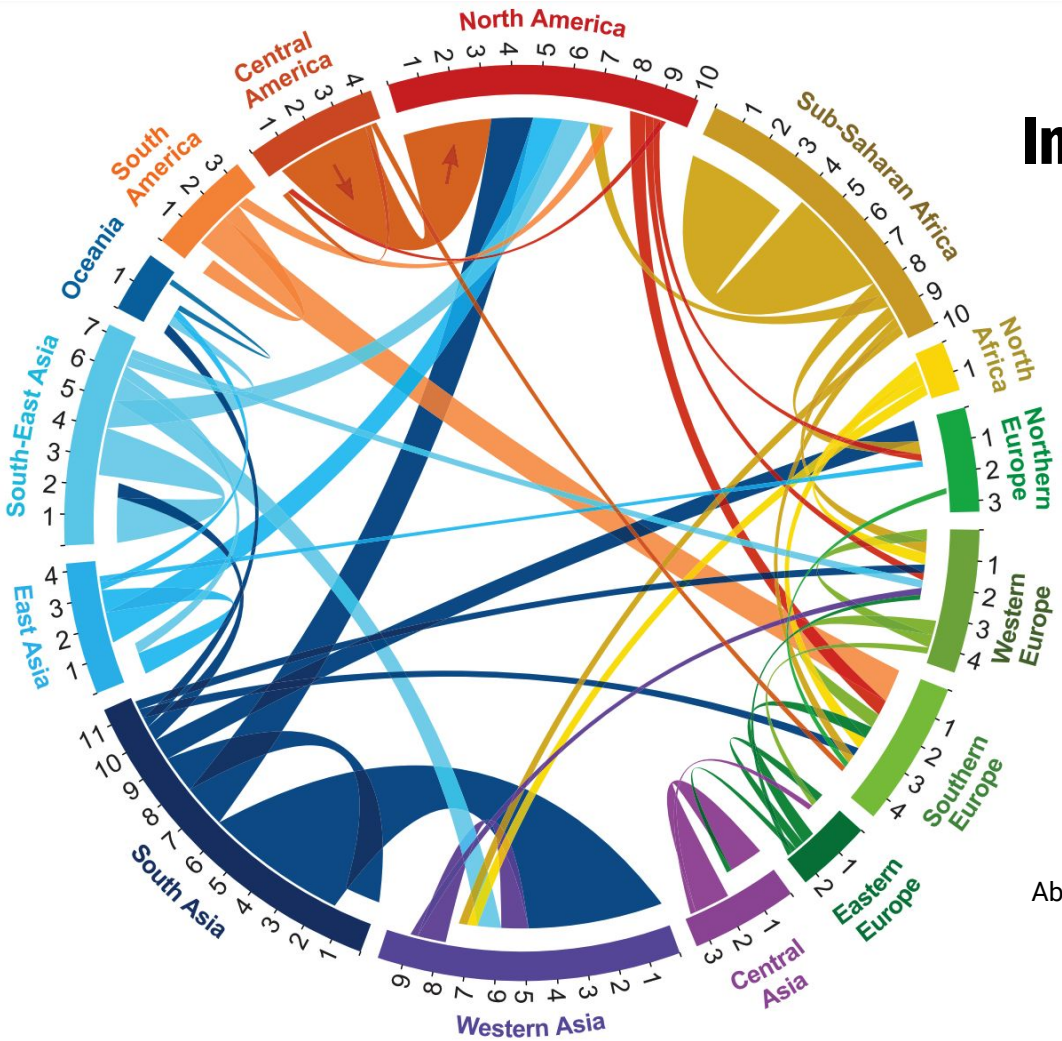
- **Volume**: the incredible amounts of data generated each second
- **Velocity**: speed at which vast amounts of data are being generated, collected and analyzed
- **Variety**: the different types of data we can now use
- **Veracity**: quality or trustworthiness of the data
- **Value**: the worth of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

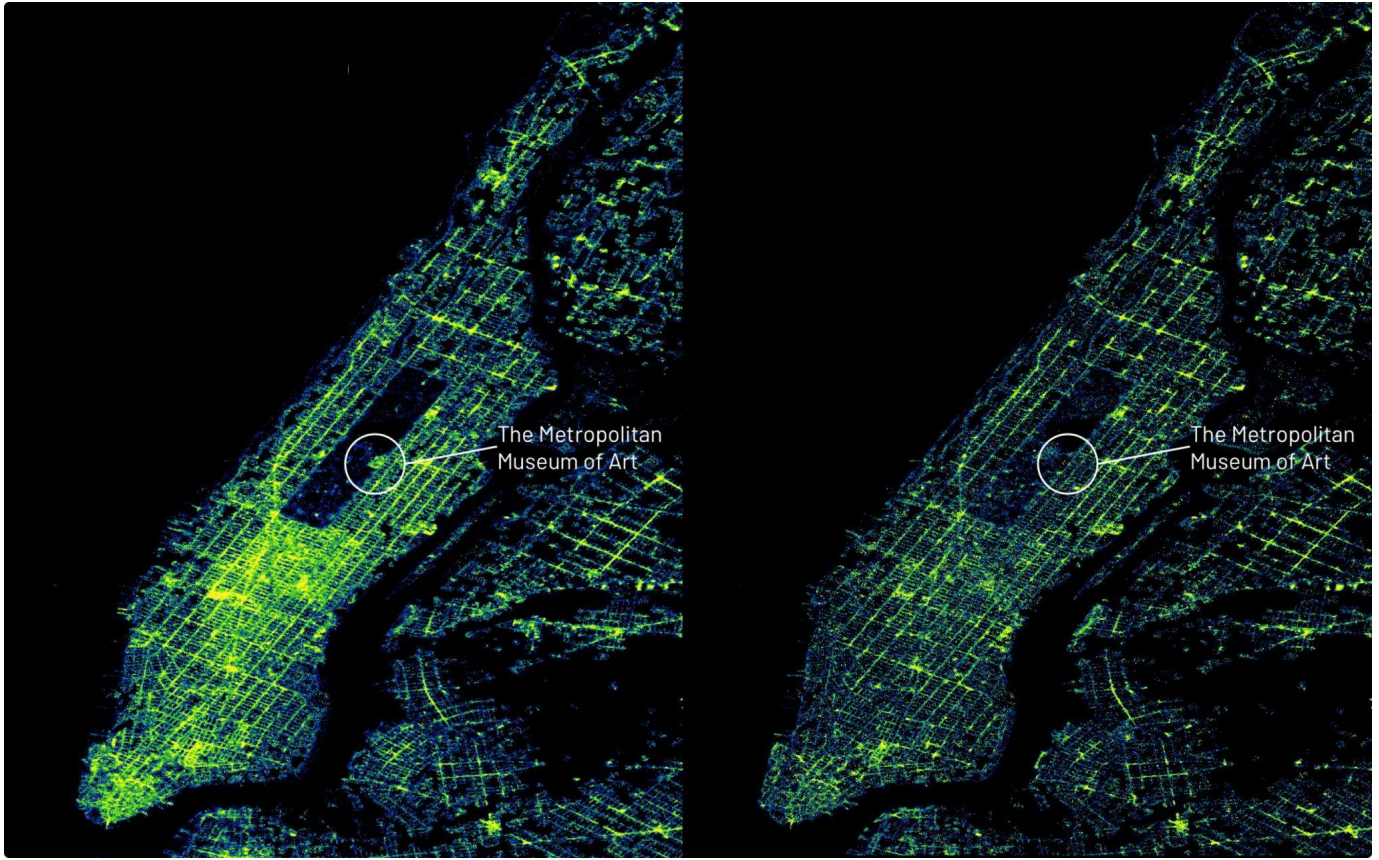


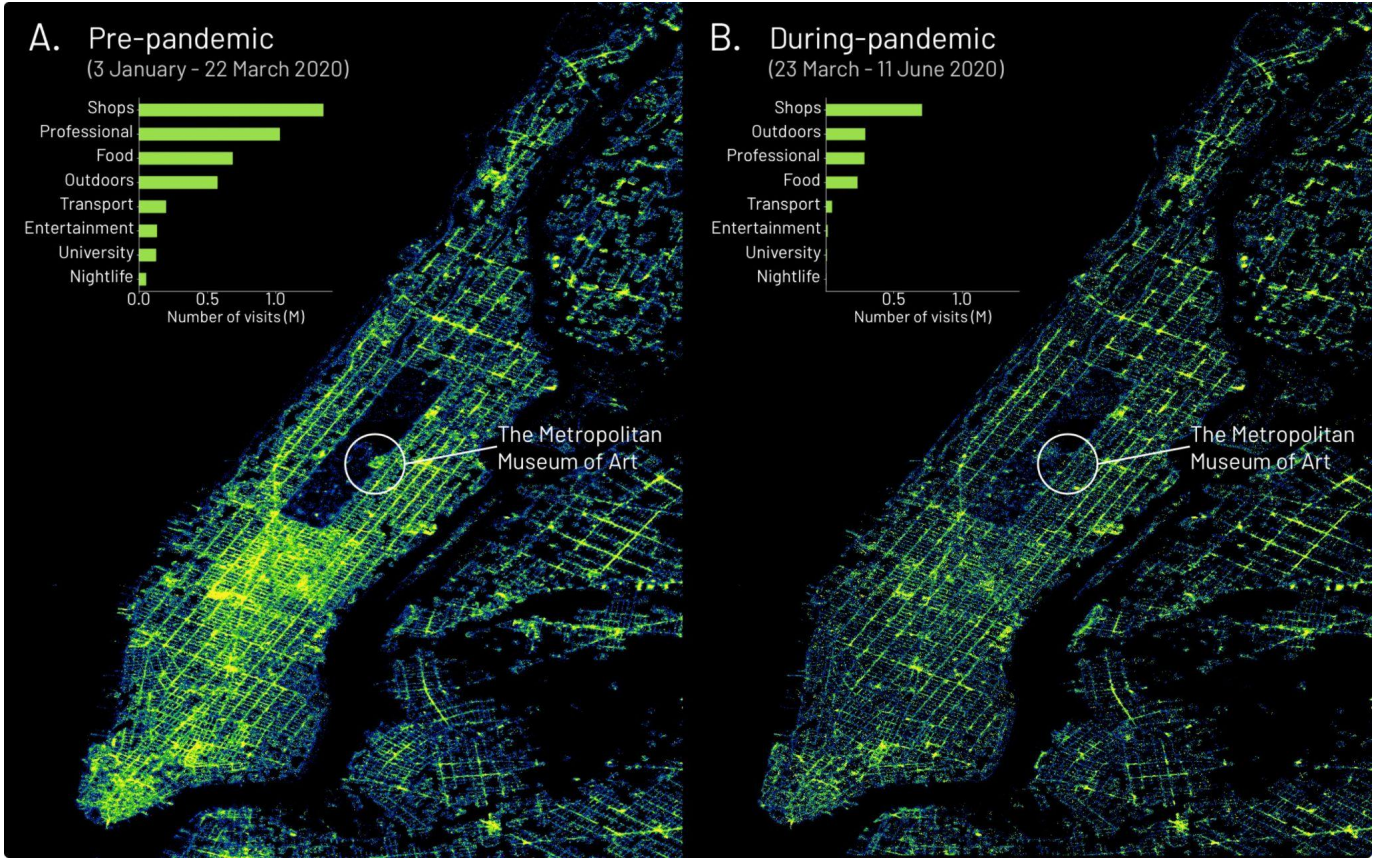
International migration flows

2005-2010

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

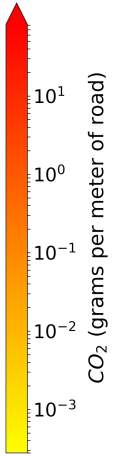
Abel and Sander, Quantifying global international migration flows, Science 343.6178 (2014): 1520-1522.

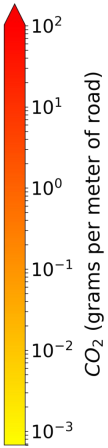

The Metropolitan
Museum of Art
The Metropolitan
Museum of Art



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

- [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)

Homeworks

Homework 1.1

Find interesting cases in history of people trying to track movements and/or migrations

- Write a blog post (2-3 pages) about it!
  - Include references (to papers, blog posts, newspaper articles, videos, or whatever)
- Your blog post could be published on the SoBigData blog